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ROBERT BEACH

ARRANGED IN SIXTEEN VOLUMES  
WITH A HISTORY OF SCIENCE, GLOSSARIES  
AND A GENERAL INDEX

SUPPLEMENTED BY A LOOSE-LEAF VOLUME EMBODYING  
THE MOST IMPORTANT DEVELOPMENTS IN SCIENCE,  
ANNUALLY, FROM 1923 TO 1932

ILLUSTRATED



VOLUME TWELVE

P. F. COLLIER & SON COMPANY  
NEW YORK

*Giraffes in their native African haunts*

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**ZOÖLOGY**  
**THE SCIENCE OF ANIMAL LIFE**

BY  
**ERNEST INGERSOLL**



**P. F. COLLIER & SON COMPANY**  
**NEW YORK**



## PREFACE

**I**N this volume, occupying the place in the series assigned to the subject "Zoölogy," the writer was called upon to survey the whole range of animal life on the globe, and to keep in view the fact that these books were to be a library of science. The casual reader, with no particular interest in natural history, seeks in such a book little more than stories of animal life thought of mainly as "big game," with an appetite for the adventurous and wonderful. But beasts and birds and snakes, although they number in the aggregate thousands of kinds, are but few compared with the almost innumerable hosts of the lower orders of animal life that dwell in the wildernesses of the world, or throng in the seas, or hover about us in the air; yet they are a part of the zoölogy of the globe, and a most important part. Although they may rarely have the picturesque interest that attaches to the vertebrate groups, they exhibit great beauty in many cases, and are the foundation on which the others rest, for they furnish the food on which the more highly organized creatures subsist. To the student this lower half is often more attractive than the upper half; and the history and philosophy of animal life could not be understood unless it was fully considered. The author has therefore devoted a proportionate space to the lower orders, at the expense of detailed descriptions of birds and beasts, knowing that these are easily accessible elsewhere. The arrangement of the matter in the volume is ac-

according to the latests results of critics of classification, and it illustrates, as well as any lineal arrangement can, the principle of the development of the higher classes from the inferior by a gradual evolution toward more and more complex forms. Space did not permit of much exposition of methods of development, as revealed by fossils; and the volume on Paleontology should be read in connection with this one.

ERNEST INGERSOLL.

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# CHAPTER I

## HOW THE GLOBE WAS STOCKED WITH LIFE

EVER since man began to think in the connected way that follows self-consciousness, he has pondered, with a mixture of fear, reverence, and curiosity, on the nature of life and its origin. The world in which he found himself was a vast mystery which, very crudely at first, he sought to penetrate. All his paths of thought led him circling back to himself as the greatest mystery of all. He struggled with the problem for thousands of years, framing fanciful guessworks, erecting elaborate structures of logic on foundations of error, emotion, and presumption, fashioning beautiful fables and theories (and waging wars to compel other men to accept them), yet found no better solution than that life must be a gift from some unknown, perhaps unknowable, source. Even lately, learned philosophers, such as Helmholtz and Kelvin, supposed it brought to the earth (in germs) by meteorites—fragments of exploded planets that had borne life before they went to destruction; or, like Arrhenius, postulated an impalpable dust, or "panspermia," scattered through all space and borne from the atmosphere of one planet to another. But all such hypotheses only threw the question of origin one step further back.

Meanwhile, beginning a few hundred years ago, when greater privilege of inquiry became possible

in a jealous society, naturalists had tried to attack the problem from a new angle. They asked themselves whether they might not, by intensive study of living things, find the quality of life itself, hoping that if that could be done the source of it might be disclosed. In their earnest work they constantly improved their methods and their instruments, and so penetrated deeper and deeper into the constitution of plants and animals, until at last they found the ultimate particle in the cell and discovered living things so simple that they consisted of one cell alone; but why that microscopic particle was *alive*, while the grain of crystal beside it, or the drop of water in which it swam, was *not* alive, remained unexplained.

Thereupon some of the naturalists fell back into the ranks of the speculative and religious persons who were content to believe the endowment of the world with life an act of a Divine Creator—something above and outside of nature as otherwise manifested; others asserted an equivalent but more materialistic doctrine that they styled “spontaneous generation,” which presently was shown to be untrue, at least in the way they formulated it; and a third group confessed that they did not know whence life came, nor were they much concerned to know.

#### LIFE CONSTANTLY ORIGINATED BY NATURE'S PRODUCTIVE ENERGY

This quest having failed—although it had taught much by the way—the chemists, who had been making marvelous discoveries in the inorganic lifeless half of nature, undertook a far more serious exploration of the organic living half. You have inter-

preted very fully, they told the naturalists, the forms, and structure, and functions of organisms, but can get no further; now let us chemists try whether we cannot find the principle of life by analyzing the *substance* of living things.

Profiting by their experience, they turned to the colloids in hope of a clue. A colloid is a substance that shows no power of crystallization, and is composed of molecules united by their own affinity, and not by atomic affinity. They have a gelatinlike nature or composition, although varying greatly in chemical composition and general character. They differ widely in stability, for instance, some being easily upset by a change in conditions; and this peculiarity is of great importance in relation to the phenomena of life, for colloids enter largely into the composition of all living bodies, but always in a delicately balanced union with crystalloids. "The colloid is in fact," declared Thomas Graham, who first investigated its properties, "a dynamical state of matter; the crystalloid being the statical condition. The colloid possesses *Energia*. It may be looked upon as the probable primary source of the force appearing in the phenomena of vitality."

Now, many of the properties of inorganic colloids approximate those found in living structures, which appear to be "alive" by reason of the conversion of the energy of the sunlight into the chemical energy of their constituent (organic) colloids. The agent in this conversion is the green substance chlorophyll in the cell or cells of the plant; and, directly or indirectly, all the energy in living things arises from this one source, transmuted by this one transformer. Yet chlorophyll is far too complex a substance to arise as a first step from inorganic matter,

even where conditions are suitable for life to appear; and the spontaneous production of such a thing as a bacterium would not solve the problem, for the new-born cell would have no organic food, and must at once perish. In an utterly lifeless planet inorganic colloids must first develop, and in time one of these must begin to evolve not a living cell, or anything so complex as a bacillus, but something in the way of a molecule holding a higher store of chemical energy than anything before it. Later such colloids, perhaps uniting with others, would begin to condense and form more complex organic molecules, and finally effect unions with crystalloids. Thus would organic complexity gradually be led up to, chlorophyll brought into being, and life appear. One of the foremost of the biochemists, Prof. Benjamin Moore, of the University of Liverpool, has summed this up picturesquely:

“It was no fortuitous combination of chances, and no cosmic dust, which brought life to the womb of our ancient Mother Earth in the far-distant Paleozoic ages, but a well-regulated orderly development, which comes to every mother earth in the universe in the maturity of her creation when the conditions arrive within the suitable limits. Given the presence of matter and energy forms under the proper conditions, life must come inevitably. . . . If this view be the true one, there must exist a whole world of living creatures which the microscope has never shown us, leading up to bacteria and the protozoa. The brink of life lies . . . away down among the colloids, and the beginning of life was not a fortuitous event occurring millions of years ago and never again repeated, but one which in its primordial stages keeps on repeating itself

all the time and in our generation. So that, if all intelligent creatures were by some holocaust destroyed, up out of the depths in process of millions of years intelligent beings would once more emerge."

That is to say, life arose through a recombination of forces preexisting in the cosmos, and the fact was but a step in the evolutionary process. "Such evolution," the American biologist, Henry Fairfield Osborn, declares with emphasis, "is essentially constructive, and . . . is continually giving birth to an infinite variety of new forms and functions which never appeared in the universe before. It is a continuous creation or creative evolution. Although this creative power is something new derived from the old, it presents the first of the numerous contrasts between the living and the lifeless world."

#### LIFE'S BORDERLAND

Although in some respects a deceptive resemblance may appear between the living and the non-living, the distinction is definite. Living bodies, plant or animal, are made up of protoplasm, which, although mineral in substance, consists of a combination never found in the mineral kingdom. It gives to the body containing it the power of growth, and this growth is by additions from within. Minerals may increase in size, but only by additions from without. The prime characteristics of living organisms is that they reproduce their kind, given favorable conditions. Minerals never do so. A correlative of life and growth is death, but minerals never die. In the course of its career every animal or plant, in proportion to its need or the degree of complexity of its organs, develops within itself characteristic compounds, such as albumin, gluten,

starch, cellulose, fat and other chemical results, not a trace of any of which is to be found in rocks or soil, or in the water or in the air. No distinction in nature is so absolute as that between the inorganic and the organic realms, the nonliving and living things, so far as our senses can perceive them.

When, however, we consider the two prime divisions of the living world—animal and vegetable—so diverse in their higher developments, we find them springing from the same base in a single cell of almost structureless protoplasm, and so alike in this simplest form as to be in some cases indistinguishable—mere drops of living matter whose functions are so limited that they present no discriminative characteristics. Indeed, marking a definite boundary between animals and plants may be difficult in cases much higher in the scale than these primitive globules of protoplasm.

A fundamental distinction between plants and animals as we now know them is the exclusive possession by plants of the green substance chlorophyll, by the presence of which their food is transformed under the influence of sunlight into vital energy in a manner essentially different from that by which animals assimilate their substance. Chlorophyll is a complex, nitrogenous, colloidal substance, produced by and always associated with, protoplasm, and related to the coloring matter of the blood of animals. It is restricted to plants, and usually resides only in definite portions of the cell; yet we have good reason for believing, as Prof. William F. Ganong tells us, that our present green plants were preceded in time by a colorless kind of the utmost simplicity, and without chlorophyll, which yet could make their own food from carbon dioxide and water

by using the energy of chemical oxidation of soil-minerals in place of sunlight. "We have precisely such chemosynthetic organisms, a kind of soil bacteria, still living on the earth at this day; and they are doubtless the lineal descendants of the ancient forms, which probably lived in the mud of shallow seas that may be full of them yet." These ancient chemosynthetic organisms were neither animal nor plant, but both and between. They must have expanded, varied, evolved, thus originating a great many branches, most of which perished.

Now, from this biochemical borderland of life, let us turn our attention to the living world as we know it to-day, or as preserved for us in the "record of the rocks," pausing only to fix well in our minds the main distinctions between animals and plants. Plants have no special organs for digestion or circulation, nor any nervous system. Most plants absorb inorganic food, such as water, carbonic acid gas, nitrate of ammonia, phosphates, silica, etc. No animal swallows any of these minerals as food. On the other hand, plants manufacture from such materials the food on which animals exist, by the production and storage in their tissues of starch, sugar, and nitrogenous substances. The two kingdoms supplement one another. They are mutually dependent, and probably originated simultaneously.

## CHAPTER II

### THE SEA A VAST AQUARIUM

NO results of investigation in natural history have been more amazing than those that show the marvelous richness of the sea in plant and animal life—not merely at its warm margin, but far out in the center of what the ancients used to call “the desert of waters”; not only at its surface, but in its profoundest depths, and under the polar ice as well as amid the tropics. Sea populations differ somewhat according to situation, those of the shallow shore lines, which are of the “littoral” fauna, differ largely from those living in the open sea and belonging to the “pelagic” fauna, and there are surface swimmers, and others confined to the abysses; but virtually every class and subdivision in the animal kingdom is represented in greater or less variety in the zoölogy of the ocean. The list stretches from the merest monads to the huge sharks and still bigger whales.

This multitude and diversity of animal life is possible in the sea because of an even greater plentitude of plants there, which furnish a never-failing food resource. Bacteria and blue-green algæ are at the base of this. Bacteria exist in all seas, as in all soils, and the fertility of nature above ground and under water depends on these microscopic organisms, whose numbers in the ocean are as incalculable as the grains of sand on its brink. In equal multi-

tude are the diatoms, unicellular algæ with flinty cases, by which the waves are sometimes discolored over broad areas; and millions of other green plants, living alone, or in chains, minute in size, but each a chemical laboratory converting the salt water they absorb into meals for the animals that swallow them—animals in most cases almost as small and simple as the things they eat, and themselves destined to be sucked into the mouth of something a little bigger, to be in turn a tidbit for a third hungry mouth, and so on to the broiled mackerel for our own breakfast.

#### THE PLANKTON AND ITS PHOSPHORESCENCE

The assemblage of plants and animals that together float or swim at or near the surface of the ocean (or other water), say within a layer of water one hundred fathoms thick, is scientifically called *plankton* of the sea. In the open ocean, the pelagic plankton is much alike all round the world of waters, although it varies a little in composition, and still more in relative abundance, being denser in temperate than in either tropical or polar latitudes; but nowhere is it absent. The “waste of waters” teems with life. The plankton of the shallow waters near continental shores, however, presents a decidedly different assemblage from the pelagic plankton.

In the pelagic plankton, single-celled animals of the groups called foraminifers and radiolarians are exceedingly prominent, and play an enormous part in the economy of the sea, although almost or quite microscopic in size. They are incased in chambered shells of lime or flint; and over vast areas in warm latitudes the ocean floor is so thickly covered with

the dead shells of one kind that the mud is called globigerina ooze. They are the eaters of the microscopic plants, and themselves are food for a wide variety of hydroids and jellyfish, large and small, whose silvery forms are often visible to the voyager, and which are mostly responsible for the pale stars of phosphorescence that shine about his prow and glorify his wake in dark nights. The queen of these far swimmers is the radiant Portuguese man-of-war. In the night a dragging fine-meshed net will capture more than by day of the plankton, because many little creatures that in daylight sink to considerable depths come to the surface at night.

Rising a step to the worms, we find them comparatively rare, but one kind of marine flatworm that abounds in midocean is rose-red and several inches long. Much more numerous is another flatworm, *Sagitta*, "which along with copepoda, salpæ, pteropoda and radiolaria, everywhere constitute the bulk of the small pelagic organisms" captured by towing nets. Like almost all of these usually defenseless creatures they are perfectly transparent, but some of them depart from the rule of pale blue in tint and shine in bright red. A longer step takes us to the Crustacea, represented in the pelagic plankton by queer little shrimplike forms that in countless hosts of individuals play a part in the ocean comparable to that of insects on land. The copepods are the most numerous probably—little things only a fraction of an inch in length, but amazingly abundant, and the principal users of plant food. Their relatives, the little ostracods, have similar habits, and are noted for their intense phosphorescence. Haeckel relates that on his way to Ceylon he saw the entire sea like a twinkling ocean

of light, and his microscope showed him that it was made by throngs of ostracods, with some jellyfishes, salpæ and worms. Crustaceans of higher rank abound also. In northern waters species of Schizopoda, small, transparent prawns with red spots around the mouth and big, black eyes, swarm in enormous numbers, and are known to the fishermen as "kril."

An important part of the pelagic plankton consists of certain small mollusks; and "as regards abundance of individuals few groups of pelagic animals can compare with the winged snails, or Pteropoda." These are minute, rapidly swimming creatures with thin, glassy shells, and in some parts of the warmer oceans these discarded shells are so numerous on the bottom that they give the name pteropod ooze to the mud. One kind (*Limacina*), with a coiled shell about the size of a pinhead, which abounds in the north Atlantic, is much feared by the Norwegian fishermen because they very often spoil the herring that feed on them. Another kind (*Clione*), looking somewhat like a reddish butterfly an inch or so long, swims in shoals in the icy seas of the far North, and is known as "whales' food." Some larger mollusks, of which the beautiful purple *Ianthina* is most conspicuous, live among the vast patches of floating seaweed in the Sargasso Sea.

Great numbers and variety of tunicates or ascidians and their larvæ are taken in the surface nets of the sea naturalists, among them the salpæ—free-swimming, barrel-shaped, transparent animals well known to all seafaring people, and often seen crowding the surface of the ocean. One genus of them is *Pyrosoma*, which has from the earliest days

excited the interest of mankind, mainly on account of the strong phosphorescent light emitted, the name, indeed, meaning "fire animal." These salpæ aggregate into colonies often several yards in length which glow like fiery serpents as they move sinuously on their way.

This property of luminosity, so widely possessed by marine animals, is one of the unsolved mysteries. It is called "phosphorescence," because it resembles the cold light given by phosphorus when undergoing slow oxidation, but phosphorus has nothing to do with the manifestation here, or in such insects as the firefly; nor is it owing to bacteria, as in the case of shining wood or decaying fish. What it really is no one knows, but it has, at least, been learned that in animals the power of emitting light is always attributable to certain structures of a glandular nature that secrete a slimy, luminous substance, or, rather, two substances, one luciferin and the other luciferase. When both together are exposed to seawater phosphorescent light results.

As a rule, the light organ is surrounded by a layer of black pigment that acts as a reflector, and often the light is projected through a transparent lens; and there is reason to believe that in the case of the higher animals, such as deep-sea fishes and squids, the rays may be thrown when and where the creature desires, as a man handles an electric flashlight. But for what purpose? Is it to illuminate the surrounding water so as to perceive, or to attract, prey, or is it to avoid foes? A learned oceanographer replies that no one certainly knows. "At all events," he concludes, "the answers would probably tend to show that the many different kinds of light organs serve different purposes."

## PRISONERS IN THE DARK AND ICY DEPTHS

So much for the surface population of the ocean—the plankton layer is regarded as a hundred fathoms thick. We have considered only that over the mid-oceanic depths, but that of the shallow margins is different simply in the absence of some purely pelagic creatures, and in the presence of vast hordes of eggs and larvæ of the animals rooted in the sand or attached to the rocks and weeds from high-water mark down to a comparatively short distance below low-water mark. These I shall speak of more completely hereafter.

Before that, however, I want to say a few words in regard to the extraordinary inhabitants of the ocean's depths—depths which in some places exceed the elevation of the highest mountains on the land.

The conditions under which animal life exists there are vastly different from those at the surface, and it is not surprising to find these creatures of an extraordinary character. The pressure exerted by water on anything lowered into it increases at a rapid rate as the object sinks, so that at a depth of only 500 fathoms it equals about 100 times the pressure at the surface. This contributes to the density of underlying waters; the saltness of the sea also adds to the water's density, but this decreases slightly from the surface downward. More important than density in its effect on living things is temperature. In the Sargasso Sea in summer the water at the surface will indicate about 52 degrees F., and at 100 fathoms of depth 48 degrees, below which it diminishes slowly to a little below the freezing point—32 degrees F. The water below a few hundred fathoms may therefore be regarded as a series of

layers measured by degrees of density, temperature, etc., and this means a series of biological strata in each of which the denizens are more or less limited by unfavorable conditions above and below them.

A fourth factor conditioning deep-sea life is that of light. The sunlight penetrates to a much greater distance than was formerly believed; and experiments with photographic plates show that the blue rays may sink as far as 800 fathoms, but the red rays go much less down. Below that glimmer is absolute darkness, illuminated only by the phosphorescent glow of the lanterns carried by the animals moving about in that Stygian and icy abode—which would seem to us the most dreadful fate to which any creature on the globe is born.

It has been said that the ocean depths seem to be divided into horizontal zones, certain groups of animals being confined, when adults, within limits of depth determined by conditions suitable to them, one zone above the other. Practically, however, these intermediate life-zones can hardly be defined, and vary in different seas, and under changing conditions, as of season, and so forth. Animals taken only by deep hauls of the nets within the tropics, for instance, may be captured in cooler latitudes near the surface; furthermore, the vertical distribution of fishes, as a class, may differ from that of crustaceans as a class. Nevertheless it is true in general that many sorts of pelagic animals dwell at intermediate depths, from which, when they have become mature, they cannot either rise or descend any great distance. Among them are representatives of all the classes of marine life.

Let us now consider the creatures of the lowest level—those abysmal depths where eternal cold,

stillness, darkness, and equability unite to make an environment so forbidding that human imagination would refuse to people it with living beings; yet where life and strife do actually exist, although by no means uniformly distributed. We know most about it as it exists in the bed of the north Atlantic.

The real bottom animals are mainly fixed—sponges, hydroids, sea anemones, bryozoans, brittle-stars, crinoids, brachiopods, holothurians, worms and mollusks. They are nowhere numerous remote from a shore, and below 2,500 fathoms are very scarce, to judge by the results of dredging. Their food comes wholly from the surface, apparently, some catching it as it falls and others sucking it out of the ooze. Moving about among these, and feeding on them, is a scanty population of snails, squids, crabs, and fishes, making their living upon or close to the bottom; and a larger and more varied company of relatives swim in the water above them up to, say, the 2,000-fathoms line. All these are of forms different in many respects from kindred species at or near the surface; and some brought up by the deep-sea dredge can hardly be distinguished from fossils entombed in the oldest fossiliferous rocks—so unchangeable is the environment in which their race has been propagated for perhaps fifty millions of years.

Through these dark abysses swim fishes with extraordinary and grotesque adaptations to their conditions. All are small, rarely six inches long, often less than an inch, yet armed to the teeth. This is especially true of the families Stomiatiidæ and Sternoptychidæ, in which one finds fishes of the queerest shape, with big heads and a savage array of long sharp teeth. All are voracious, for food is

scant and must be fought for; and some, as *Chiasmodon*, have mouths so capacious that they often swallow fishes larger than themselves, when their stretched stomachs hang beneath their slender bodies like the yolk sacs of newly born trout. All are dark in color, brown, blue or violet marking the abyssal species. Some of them have light-giving organs; and this was formerly regarded as a peculiar possession of deep-sea fishes, enabling them to see their prey in the gloom of their habitat, but it is now known that light-giving organs are especially characteristic of pelagic fishes of the region between the surface and 250 fathoms of depth. It must be remembered, however, that the sedentary invertebrates of the bottom glow with phosphorescence.

This outline of a vast body of information shows that the waters of the oceans are everywhere inhabited, to their uttermost deeps, by living beings; that these are adapted to various circumstances, and so form faunas of local extent and character; and that probably the sea derived its wealth of population—at least all that part superior to the monads—from the land, beginning with the earliest dawn of life on the globe.

## CHAPTER III

### A CHAPTER OF FOUNDATIONS

#### THE NATURAL BASIS OF CLASSIFICATION

I MENTIONED in my introductory chapter that the simplest form of animal was one whose whole being was contained within a single envelope, or "skin," called a cell. Such a cell contains nothing but that strange primitive life-substance named protoplasm, condensed at one point into a nucleus, and it is precisely of such cells that the bodies of all the animals we commonly know are made up; nevertheless an immense variety of creatures still exists, especially in the plankton of the sea, that, like those at the dawn of life, consist of one cell alone. Here then we stand at the first grand division of the animal kingdom:

A. Animals consisting of a single cell—*Protozoa*.

B. Animals composed of an aggregation of cells—*Metazoa*.

This distinction, you see, is one of structure, as must be all the subdivisions that follow, if they are to be natural; and it is the clearest possible illustration of what we mean in zoölogy when we speak of "lower" and "higher" rank, for it is evident that it is a step upward, an advance from utter simplicity to greater and greater complexity, to proceed from a single-celled, all but helpless animalcule to one composed of many cells, with so vast a division

of labor and extensive power of action as belong to such a combination of forces.

I do not propose to describe the Protozoa, because both of lack of space and lack of popular interest; anyone may learn about them in any good zoölogical textbook. But I do want to mention one very important point, on account of its bearing on the history of the higher animals. The protozoans reproduce their kind by simply splitting into two individuals, and these again split into another two, and so on; the process is called "fission." There comes a time, however, when the ability to do this ceases, and the protozoans of this strain will die out unless one or more of them meets with the same kind of animalcule, and the two "conjugate," or merge into one another, thus renewing their power to go on dividing.

Turning now to the Metazoa, or animals in general, we may say that they are flexible and usually motile beings, needing a supply of solid food which they convert by digestion into a fluid form, and then diffuse through their tissues. This accounts for the fact that all animals consist essentially of a tube, which in the simpler forms is very apparent. This typical tube consists of at least two layers—an outer, protective, and sensitive coat (ectoderm), and an inner, digestive one (endoderm). This two-layered condition is the limit for a few freshwater and a vast number of marine animals therefore called "coelenterata," of which the jellyfish and corals are examples. The two coats are separated, and at the same time connected, by a greater or less amount of a jellylike filling called the "mesenchyme." Into this intermediate mesenchyme both ectoderm and endoderm bud off cells which have

certain functions—that is, they circulate the digested food, perform the creeping movements when such occur, expel the waste of the body, and most important of all, provide the germ cells by which the race is perpetuated.

Now in animals superior to the jellyfishes and the flatworms, the mesenchyme is replaced by a definite hollow tissue that produces a more efficient system of muscular, excretory, and reproductive organs. This hollow tissue is the “cœlom,” and in the most advanced animals, such as the chordates, “the cœlom and its products are of the greatest importance, for they give rise to the vertebræ and the muscles, and in so doing mold the shape of the fish, amphibian, reptile, bird, and mammal.”

In this brief sketch of some broad distinctions among the masses of animals we have a hint of the basis of their classification.

#### ANIMAL LIFE IN ORDERLY ARRANGEMENT

Classification is really only a sorting out of things into groups of the same kind. It may be artificial, according to fancy or convenience, or it may be by discovery of nature’s inevitable development. It has been done crudely ever since men began to show curiosity about the things around them. They spoke of animals of the land, of the water, and of the air; of those that lived on vegetable fare as different from the flesh eaters; and in a more particular way they recognized various obviously like and unlike groups within the larger ones. All these distinctions were made on external appearance or behavior, and closer observation presently showed bad combinations, such as placing bats with birds simply because both flew, or whales with fish because both

lived in water. Slowly it became evident that the only proper way to classify animals was by putting together those of like structure, and this could be accomplished only by intense comparative study of the interior anatomy of their bodies. Even here, however, progress was limited until the great light from the idea of organic evolution fell on biological science, by which it was perceived that the true criterion by which the proper place of any animal could be determined was its line of descent—a matter wherein the student of fossils could render, and has rendered, vast assistance. In other words a real, natural classification is according to ancestry, just as human relatives are grouped into families according to their known descent from the same forefather.

In this evolutionary light zoölogists have now perfected, at least in respect to its larger divisions, a classification of the animal kingdom which is generally accepted, and is followed in this book. It proceeds, reading downward, from the simpler and older forms of animal life to the more complex and more recent forms.

As to the names and relative order, or rank, of the subdivisions that we shall have occasion to mention, a few words are desirable. The only real fact is the individual animal. A collection of these so similar that they cannot be divided, and which will interbreed, but usually are sterile as to other animals, is termed a *species*. A number of species closely similar are bracketed together as a *genus* (plural *genera*), and this done, every individual is given a double name, as *Felis leo* to the lion, the first part of which indicates its genus, and is called its “generic” name, and the second indicates its species,

and is called its "specific" name. This "scientific name" is given in Latin (or Latinized Greek) so that it may be unmistakably understood in all parts of the world, for a local name in one language would mean nothing to a student speaking some other language, or perhaps speaking the same language in another country; thus the name "robin" is applied to half a dozen very different birds in separate parts of the English-speaking world, and endless confusion would result were not each animal labeled in a language understood by everybody; and this must be a dead language, so that the significance of the terms applied shall not vary in place or time.

Several similar genera may form a *family*; families that agree in essential characteristics are united as *orders*; orders are grouped into *classes*; and finally like classes are assembled into a *phylum* (Greek, "a leaf": plural *phyla*), which is the largest division except the primary distinction of Protozoa and Metazoa.

## CHAPTER IV

### THE HUMBLEST OF ANIMALS— SPONGES

AT the foot of the arrangement of phyla in the metazoa stand the Porifera, or sponges, fixed, plantlike, queerly shaped beings living in the sea, except one family in fresh waters, and abundant in all the warmer parts of the world on rocky bottoms. Whatever its size or shape, a live sponge (of which the commercial article is the more or less perfect skeleton) is coated with a thin fleshy membrane perforated by minute "inhalant pores" and larger holes termed "oscula," or mouths. Through the inhalant pores the sea water, with its burden of microscopic food, enters one of many spaces beneath the surface from which incurrent canals penetrate the interior of the sponge, constantly branching and growing smaller until lost to sight. The fine tips communicate with small cavities lined with cells that are fitted to seize and assimilate the nourishment brought them by the water. From these rudimentary stomachs go similar excurrent ducts that unite near the surface into trunk canals that carry out the used water and waste products. This system of circulation, bringing nutrient water strained through the pores, and expelling it forcibly after it has been cleared of food value, is kept in motion, with occasional periods of rest, by the action of "flagellate cells" that line certain tracts in the

canals. These are elongated cells from which project whiplashlike filaments, one to each cell, whose movements in concert "resemble those which a very supple fishing rod is made to undergo in the act of casting a long line"—the movement being much swifter from without inward.

Beneath the outer skin, and all among the canals and cavities, is a filling of gelatinous materials, largely protoplasm, in which are formed great numbers of variously branched and strengthening spicules, of limy material in one group, and in others of a flinty or glassy nature, or in the absence of these, a network of "spongin," such as forms the skeleton of our common washing sponges. Spongin is a substance allied to silk in chemical composition, and the threads are felted together in such a way as to form a firm, yet elastic structure. "In some Noncalcareous, which are devoid of spicules, the place of these is taken by foreign bodies—shells of Radiolaria, grains of sand, or spicules from other sponges. In others again, such as the Venus's flower basket (*Euplectella*), the glass-rope sponge (*Hyalonema*), and others, the skeleton consists throughout of siliceous spicules bound together by a siliceous cement."

Sponges are reproduced both by budding in some form, which is an asexual way, and by the sexual method of eggs and male cells; these are formed in the same sponge, but rarely at the same time, and the early stages of development are passed in a brood-cell within the body of the parent sponge. Finally, the embryo escapes through one of the outgoing canals, swims about awhile, becomes thimble-shaped, and settling down, fastens itself by the closed end to some patch of mud, a rock, dead shell

or seaweed, closes the open end of the "thimble," and proceeds to grow.

Sponges do not appear to be eaten by fishes or anything else. Countless lower animals, such as marine worms, mollusks, and so forth, burrow into them, however, in search of shelter; and in reversal, certain small sponges, such as the *cliona* of our shores, burrow into the shells of mollusks, which explains the honeycombed appearance of many of the shells picked up on the beach. Sponges have a large part in that very interesting and widespread phase of marine life called "commensalism," in which two animals become intimately associated in a mutually beneficial way, and are thus spoken of as messmates. Some kinds of sponge are never found growing except on the backs or legs of certain crabs; the sponge conceals and protects the crab, while itself benefits by being carried from place to place, with constantly new changes of fresh water and food. This sort of partnership occurs in many different groups of marine animals.

The capture and preparation of sponges for market employ thousands of men and boats in the eastern Mediterranean, whence the best are derived, and in the West Indies and Gulf of Mexico, where the sponges are of a coarser kind, and are gathered and prepared by rougher methods. They are taken commercially also in other seas, and frequently dredged from vast depths.

## CHAPTER V

### FLOWERS OF THE SEA

#### JELLYFISHES, NAMESAKES OF THE FABLED MEDUSA

THE type and simplest form of that great division of aquatic, and almost exclusively marine, animals constituting the phylum Coelenterata, is the polyp. It consists of a soft-skinned body, typically cup-shaped, containing a baglike digestive cavity, or primitive stomach, open at the top, and surrounded by the soft mesenchyme. The open upper end is the mouth, which is usually encircled by few or many tentacles—hollow outgrowths from the wall of the tubular gullet. Currents of water are drawn in by waving cilia at one end of the slitlike mouth, and pass out as waste at the other side; they bring food and oxygen from which nourishment is absorbed by the cells of the wall of the stomach (endoderm). Certain outgrowths within the mesenchyme act as feeble muscles for lengthening and shortening the body and tentacles; but there are no blood vessels or excretory organs.

Most polyps are fixed on some support, but in many the young pass through a free, swimming stage before settling down for life. All coelenterates, and these only, are provided with "stinging cells," the nature and importance of which will be explained presently.

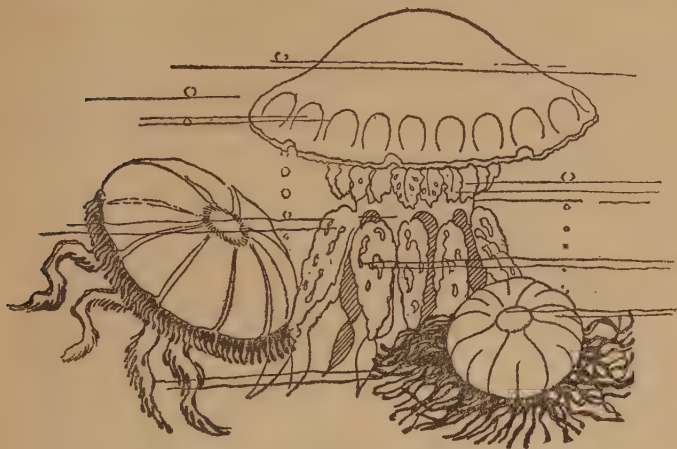
The simplest class is that of the hydroids (Hydrozoa), the type of which is the fresh-water hydra,

so-called because, like the Hydra of ancient myth, when it is cut to pieces each part will grow into a new animal. It lives in ponds and pools of stagnant water, and is so small that a magnifying glass is necessary to study it, especially in the case of the green one of our two common American species—the other is brown. Indeed, similar hydroids of salt water are often taken and dried by unscientific collectors under the impression that they are feathery seaweeds. It is stalklike in shape, has long tentacles which always turn toward the greatest light, influenced like certain plants by heliotropism, and feeds on minute crustaceans and other minute organisms. Sometimes hydras are so abundant as to form a velvety surface in warm pools. The sexes are combined in the same individual, and the embryo forms within the body, then protrudes as a bud, which finally breaks away and after a time sinks, attaches itself at the base to some support, and grows into a perfect hydra. When quiescent or alarmed the tentacles are withdrawn, and the whole animal shrinks into a little lump.

Such is the general natural history of the group; but the oceanic hydroids have developed a vast variety of forms, and, with increased breadth of life, have added many interesting features and habits. Many of them are single, rooted in mud, or upon seaweeds, rocks or shellfish both dead and alive, and look like flowers of lovely tints; and they reproduce by putting forth separate reproductive parts, called "zooids," of various kinds. Others are in colonies that spread by extensions of the base from which arise other hydroids until a bunch of them are growing side by side; but these groups consist of hydroids differentiated into separate

functions, for some devote themselves to capturing food which nourishes all, through the common base, while others produce the buds and eggs by which the colony is increased.

The most remarkable of these processes of reproduction is that which is represented by the jelly-fishes so abundant in all seas, and so beautiful either



#### JELLYFISHES

(*Medusa aurita*. *Rhizostoma cuvieri*. *Cyanea capillata*)

when seen floating along just at the surface of the summer sea, or when at night they glow with phosphorescence like silvery, greenish rockets in the dark waves. Sometimes they occur in enormous "schools"—as we say of fish—all of one kind, filling the water thickly as far as one can see, and now and then in late summer are cast on the beach in long windrows. They range in size from a pinhead to ten or twelve feet in diameter, So big a *Cyanea* would probably weigh fifty pounds, but after a thorough drying would yield only a few ounces of

semisolid matter, 99 per cent of the creature being water absorbed in its spongy tissues. Some are egg-shaped, others like a bell with a long clapper, but the ordinary form is that of an open umbrella, usually fringed about the edge with tentacles, sometimes short and fine, sometimes few and long, again a crowded circle of long snaky appendages. These elastic hanging tentacles are the means by which the medusa (as such a jellyfish is appropriately termed in science) captures its food, which consists not only of the minute things swarming in the plankton, but of other cœlenterates, small crustacea, fishes, anything in fact that it can entangle in its sticky net and sting to death. Every one of the filmy tentacles is thickly studded with microscopic cells (cnidocytes) covered by a mere film, and having a spinelike trigger projecting from it. If this trigger is touched, or the film broken, out springs the coiled thread dart which is barbed and carries into the wound it makes a poison that benumbs. Thousands of these microscopic darts may prick the skin of a captive, and paralyze its strength—as it does that of a man who gets caught naked in the trailing net of one of the great northern medusæ. Being thus captured, the prey is drawn up to the mouth, which opens in the center of the under side of the umbrella float.

At intervals around the margin of the umbrella are small organs by which, it is believed, the creature maintains a sense of balance and direction, and perhaps of temperature or light, or both; for many medusæ sink out of sight by day and come to the surface at night; and when the sea is rough they descend to quiet depths. Thus they have the power not only to move ahead by the alternate contraction

and dilatation of the disk, but to so alter their specific gravity as to sink or rise at will. They thus show the rudiments of both a muscular and a nervous system.

Very interesting, and often of great beauty, are the free-swimming, colonial, hydroid polyps called siphonophores. On a long stem or string are arranged, at the top, a bulb filled with gas or air, as a float, then a series of swimming bells whose pulsations carry the colony about, beneath which are various polyps and tentaclelike appendages, some to gather food, whose digested products circulate through the whole colony, others performing reproductive functions. The variety of form is considerable; and one of the most peculiar, and the only siphonophore familiar to most persons, is the exquisite Portuguese man-of-war, whose prismatically tinted bulb, as big as one's fist, is commonly met with in the Gulf Stream in the North Atlantic, and often is seen in great flocks in the tropics, bobbing on the surface of the waves in calm weather. Beneath that bulb trails a long tuft of tentacles and zooids, performing various functions, and so foreshadowing the division of labor that in the higher animals is effected by the different limbs and organs.

#### SEA ANEMONES, CORALS, AND SEA FANS

Sea anemones are simply large polyps of more complicated structure than the hydroid polyps. Instead of a simple, baglike, enteric cavity, the slit-like mouth admits food into a flattened gullet which leads to an enlarged digestive cavity. The gullet does not hang free, but is joined to the outer wall of the body by a series of radiating partitions, between which shorter ones extend from the inner

surface of the ectoderm; and below the gullet the stomach wall extends in lobes between these partitions, through which holes permit the nutritive juices to circulate throughout the whole body. The whole upper surface of the polyp is covered by short tentacles arranged in circles. A current of water, induced by waving cilia, is constantly flowing in at one corner of the mouth and out at the other, supplying the animal with oxygen and a certain amount of minute food, and carrying off waste; but the anemones capture by means of their tentacles small fishes, mollusks and everything that can be caught and swallowed. As some anemones exceed a foot in diameter, large and powerful prey may sometimes be taken. It is interesting to note that anemones distinguish very quickly between what is good to eat and what is not. Most of them are sitting near shore on rocks or in tide pools, or are clinging to the larger seaweeds or clustered on the supports of wharves where the waves and tidal currents are continually washing about them, often with much violence, and dashing against them strands of weed or the small wreckage always floating in such a place. None of this is seized, or at least is not swallowed; but whether we are to conclude that this choice is made by intelligence, or only by chemical perception is a matter for study. When harm threatens, or when they crave rest, they withdraw all their gorgeous tentacles, infold them within their mouth, and shrink down into roundish gray lumps that attract neither the eye nor the appetite of any marauder.

The coral polyps differ from anemones only in details of structure that we need not consider, except to note the striking difference that here the

base and the radiating partitions instead of being membranous secrete a firm skeleton either of lime or of the horny material termed chitin. The flesh overflows the walls, folding down from the top, so that the skeleton becomes really internal, although naked at the broad base. Some of the tropical stony corals are like big anemones, several inches across; and it is only when they infold all their richly colored tenacles and become a dull and shapeless lump



CORALS

Tree coral (*Dendrophyllia nigrescens*). Tuft coral (*Lophophyllia proli-fera*). Fan coral (*Euphyllia pavonia*). Cup corals and skeleton (*Carophyllia smithii*)

that their stony cup is revealed. These are solitary, and form loosely lying corals, like that called the "mushroom." New ones are produced by the parent throwing off buds which for a time remain attached by a stalk, but finally fall off and settle down to grow—a process that may go on for a score of years. In the case of the huge coral masses called madrepores the buds remain attached to the parent. If they spread out naturally, W. Saville Kent explains, they

build up by accumulation the large rounded masses known as "brain" corals and "star" corals, which are most numerous on coastline reefs, or form the base of the outer barrier reef. On the other hand, where the budding is terminal, or oblique, branching, treelike growths result in "staghorn" and similar forms.

The coral animals do not alone construct the reefs. Stony hydroids (millepores), shells of all sorts of mollusks, limy sea mosses (Bryozoa), animalcules and diatoms and various algæ stiffened or cased with lime or flint, and blown sand, contribute to build them up, especially when they near the surface of the sea.

The distribution of reef-building corals is interesting. At present they are limited to about 35 degrees each side of the equator, but are irregularly distributed, owing mainly to differences of temperature in the water, which must not be colder than 68 degrees F. Hence they exist farther away from the equator in the path of warm ocean currents. The Gulf Stream accounts for the coral islands along the coast of Florida and in the Bermudas, which is their farthest point on the American coast; and the warmth of the water accounts for their extensive presence along the eastern coasts of Australia and Africa, when few exist on the western sides of these continents; similarly the western coasts of South and Central America are nearly free of coral banks. Other causes of limitation exist. For example, the noticeable absence of coral growth along the coast of South America is largely, if not altogether, owing to the fresh water and silt brought down by the great rivers there—both prejudicial to coral life.

Coral colonies increase and ultimately form banks wherever warm, pure sea water is constantly present, and not more than about 125 feet deep. Here, spreading and continually rising on the skeletons of dead generations, they form a long line close to the land called a "fringing" reef; and outside of this, beyond a space swept by the currents, may arise a second, still more flourishing bank, termed "barrier" reef. The great barrier reef that extends for 1,200 miles along the eastern coast of Australia—a vast chain of banks and islands—is an amazing example of what these minute animals can accomplish, given time; and geology can point to still more stupendous results of their work in the early history of the globe.

Very characteristic, in the great coral-growing region of the South Sea archipelago, is the ring-shaped island or "atoll," which incloses a quiet lagoon, usually with an open entrance. The reason for such a form has excited much discussion, one explanation being that its origin was about a small island that slowly subsided, the coral keeping pace in rising as the island sank, until finally the land disappeared; another that the circular reef arose from a submerged elevation, and when it came near the surface ceased to grow except on its outer border because it ceased to get suitable water and food, until after a time the central part died out, leaving a ring. Both explanations may be true of different situations.

When a reef comes near to the surface the branching coral is knocked to pieces by the waves, and there are added to this breakage shells and bones, calcareous seaweeds, and what not; and all this is ground into sand by the surf, washed high on the

top of the ridge and manured by dead plants and animals, and by the droppings of birds, until finally a soil forms beyond the reach of the tides. Then, if it is in the far southern seas, a drifting coconut may lodge there and be rolled high enough to be left to strike its roots into the sand and begin the grove that by and by will make the islet attractive to men. The thick husk of the coconut resists harm from sea water, near which this palm prefers to grow in just such a sandy, shelly soil as the uprising reef affords. The nuts that so often fall into the surf or are carried out by rivers make long voyages without losing their vitality. Here, again, the situation of most coral islets in the course of currents is advantageous, for thus not only these nuts but other useful seeds and colonizing elements drift directly to their doors, as it were. Birds, wandering widely over the waters, espy the bit of land, and aid by their visits to increase its fertility and often add to its flora. Reefs near shore, especially in Florida and southward, become jungles of mangroves, which not only spring from floating seeds but send down from their branches sprouts that become rooted in the mud and spread the growth interminably. Such a "mangrove key" soon attracts an extensive population of plants and animals and speedily becomes a considerable island.

A great variety of corals, however, are not reef builders, and some species secrete little if any lime; these solitary relatives are found scattered all over the oceans, in deep water as well as shallow, wherever the bottom is suitable, and an immense amount of interesting information about them is to be found in books devoted to this beautiful group of animals.

The class includes two or three other orders of coral—polyps that grow in a solitary way or in groups, forming those elegant objects called sea fans, sea pens, and so forth, which can be referred to only briefly. One of these is the order Alcyonaria, in which some are soft-bodied, others are strengthened by a network of spicules. A very beautiful one is the “sea pen,” which takes the shape of an ostrich plume; another is the strange mass of parallel tubes called organ-pipe coral; and some of them are very large, the great tree coral of the eastern Atlantic depths being sometimes as tall as a man, while it looks like a sturdy, leafless tree. As in all the others, however, it is covered by a living fleshy coat of protoplasmic substance studded with polyps whose gay colors and waving tentacles give it the appearance of being clothed with minute sessile blossoms. The best known of this group, probably, is the red coral of commerce, which is the scarlet, ivorylike interior stem of a branching alcyonarian colony. This coral has from the earliest time been cut into cameos by lapidaries, as well as used for making necklaces and other toilet ornaments.

# CHAPTER VI

## UNINVITED GUESTS

### FLATWORMS, FLUKES AND TAPEWORMS

THE phylum Platyhelminthes follows the coelenterates in the ascending series of zoölogical classification, and includes a baneful company of creatures badly called "worms," which show none of the segmented or ringlike form of body that characterizes the true worms of the phylum Annulata to which we shall come presently. On the contrary, they are a group of small, soft-bodied, flattened animals, which first show that two-sided character, or bilateral symmetry, which has apparently been absent from all the groups we have studied hitherto, whose members are circular or globular in shape, and whose organs, in the adult, are arranged radiately.

The simplest are the planarians (Turbellaria), which live a free life, as a rule, although some are parasitic. They are little, thin, leaf-shaped creatures that creep on the bottom of ponds and even of deep lakes, or swim in the sea, and feed upon algæ and minute animals.

Similar to them in appearance are the flukes (Trematoda), of which the best known of a large variety is that which infests sheep. Most of the trematodes are parasitic.

The third class of flatworms is the Cestoda, the members of which are universally parasitic, and are

known principally as "tapeworms" in reference to their form.

The phylum Nematothelminthes contains an assemblage of related worms, some marine, but mostly living in fresh waters or on land, which are eellike in form, very slender, and often have amazing length. The first and lowest class is that of the nematodes, of which the minute "vinegar eels" and "paste eels" are familiar examples. The remainder of the nematodes are parasitic, and many of them are dangerous parasites.

In an allied family and genus (*Trichina*) is placed one of the most dangerous of human parasites, the *Trichina spiralis*.

Here, too, comes that "hairworm" (*Gordius*), which most country folks call "hair eel" or "hair snake." Many assert with the most positive faith that if you will soak a horsehair in water it will "turn into a snake," and will show you this long threadworm in a horse trough to prove it. I never knew a cautiously made experiment in that direction to succeed; nevertheless the fanciful error survives. The *gordius*, which does look like a hair from a gray mare's tail, is somewhat aquatic in its habits.

## CHAPTER VII

### DWELLERS BETWEEN TIDE MARKS

#### THE COLONIAL MOSS ANIMALS

SEAWEEDS and rocks at and below the limit of the ebbing tide are often covered with small bushy growths, or with lacelike incrustations that are alive. These are moss animals, representing the class Polyzoa of the phylum Molluscoida. They are minute, soft creatures that live in colonies formed by the repeated budding of the members, all connected by a fleshy base so that each contributes to the nourishment of all. "Each little animal occupies a separate stony or horny capsule, into which it may withdraw and even close the opening with a lid. . . . The mouth is surrounded by tentacles that in many species arise from a horse-shoe-shaped or disklike base. These tentacles are always beset with hairlike bristles which by their movements serve to set up currents, and thus to drive minute organisms into the mouth."

A typical example of these polyzoans (or bryozoans) is *Bugula turrita*, so abundant wherever our northeastern coast is rocky that the rocks below tide level appear covered with its mossy tufts, which are often ten inches long and profusely branched. The main stems are orange-yellow, while the terminal branches are yellowish white. The delicate tracery so frequently seen on the fronds of kelp, and on shells and stones along both shores of the

Atlantic indicate colonies, or their remains, of the lace coralline (*Membranipora*) ; and the dull red or pinkish crust so common on shells and stones in shaded tidepools represents successive colonies of the "red-crust" polyzoan (*Escharella variabilis*), layer crusting over layer. A similar history accounts for the curious nodules called "false coral" so common in moderately deep water in Long Island Sound. Similar polyzoans, which exist in great variety, both modern and fossil, contributed extensively to the formation of the older strata of sedimentary limestones.

#### ANCIENT LAMP SHELLS

Associated in structure with these minute colonists is the ancient race of brachiopods (*Brachipoda*, "arm-footed") or lamp shells, although they much more nearly resemble bivalved mollusks, whence, by the way, comes the name of the phylum to which both belong—*Molluscoida*, which means "mollusklike."

The race of the brachiopods goes back to the beginning of the geologic record. A few living examples are still found in the ocean, some of which, as *lingula*, have changed so little that they can hardly be told from the most ancient fossils of their family. Certain species are dredged abundantly on both coasts of the Atlantic from water a few fathoms deep where the bottom is rocky. They look like small mussels at first sight, but on examination show a vast difference in structure. The bivalve shells, instead of growing on the right and left sides of the animal, as in bivalve mollusks, cover its back and front, and the head parts are at the gape of the valves. At the hinge end of the shell the lower

valve overlaps (it is the shape of this lower shell, like that of an old Roman lamp, which suggests their common name, "lamp shells") and the hinder end of the body projects as a stalk, by which the animal fastens itself to the rock. "The mouth in the brachiopods is flanked by two curiously coiled and feathered arms which lie within the cavity between the shells, and are supported by skeletal rods attached to the upper shell. These serve as gills, and also to capture the minute creatures upon which the brachiopod feeds."

Owing to their great abundance, world-wide distribution, and remote antiquity, as well as their excellent state of preservation, brachiopods occupy a very conspicuous rank among extinct invertebrates, and furnish us besides with a large number of important index fossils. They are to be found in immense variety from the Cambrian to the present, most numerous in formations from Silurian to Permian times.

#### STARFISHES, SEA URCHINS, AND TREPANGS

We have now arrived at the point (phylum Echinodermata, "spiny-skinned") where a distinctly new type of interior structure appears in the possession by animals of a hollow space (coelom) between the outer skin and the wall of the digestive tube which now becomes occupied by definite organs instead of by an almost uniform mesenchyme, as in the sponges and coelenterates. These organs arise from an interior lining membrane called "mesoderm."

Henceforth, therefore, we shall deal with coelomate animals, among which the echinoderms are lowest in rank. The simplest of them is the "sea lily"



STARFISH AND OTHER TYPICAL LIFE IN A TIDE POOL

Photo, American Museum of Natural History



Photo, American Museum of Natural History

CORAL FORMATIONS OF THE GREAT BARRIER REEF,  
AUSTRALIA

which lives rooted on the bottom in deep water, and sways about on a slender, jointed stalk, looking much like the flower after which it is named. It is of interest chiefly as a survivor of the tribe of crinoids that were so varied and numerous in early Paleozoic times that massive Devonian limestones are composed largely of their remains; and the type has changed little through the ages. It consists typically of a cup, mounted on its stem like the calyx of a flower, and composed of circles of calcareous plates, definite in form and in relative position, that contain and protect a well-organized body. Surrounding the open mouth of the cup is a circle of long, jointed, much-branched tentacles that sweep the water, capture passing prey, and bring it into the mouth of the crinoid within the circling base of the arms.

If now you were to cut off its stalk, lay the crinoid on the sand, mouth down and arms outspread, beside a brittle star or a basket fish, which also have many-branched arms, it might be difficult to tell them apart, yet they represent different orders; and from this, by way of the naked serpent star, it is but a short transition to the starfish, where the arms are no longer tentaclelike, but are simply pointed extensions of a central body; this, in fact, is the case, for now they are no longer prehensile organs, but are supports, mainly serviceable in locomotion, and the stomach and ovaries are partly lodged in them. The main point just now, however, is the fact that here, and in the successive changes of form to be shown, the pattern of plates that form a strengthening mosaic in the skin of the central part of the body remains identical.

All starfishes are not as prettily symmetric as our familiar five-finger. Some are shorter in the arms,

and much broader and thicker in the body; and if you will examine a collection of preserved specimens of the echinoderms you will see that you can trace gradation of form right around to the bun-shaped cake urchin, on whose top the five-pointed star is printed, and thence to the globular sea egg, which the French called "sea urchin," using one of their names for the hedgehog. Furthermore, the five sections of the shell of the urchin, which represent the five arms of the starfish folded forward and grown together into a spherical case, are to be traced again, outlined by appendages, in the elongated and leathery hide of the trepangs and sea cucumbers of the order Holothuria.

It is as an illustration of homology, that is, the resemblance between parts that have the same relation to the typical plan of structure, and as an example of how almost endless variations of form may arise within a single type, that the echinoderms are of most interest. Otherwise it may be said that they serve as food for fishes and some other creatures, including coastwise savages, and as curiosities in geological museums and in aquaria; and that starfishes are sadly destructive of cultivated oyster beds. We may therefore dismiss them, and devote a page or two to the worms.

#### EARTHWORMS AND BEACHWORMS

Although various parasitic creatures have been described as flat "worms," round "worms," and so forth, naturalists regard as true worms only those of higher organization classified in the phylum Annulata, or annelids, the distinctive characteristic of which is that its members have elongated bodies divided into ringlike sections. These represent a

division of the internal parts into a series of structural segments or "matemeres," each supplied with its own set of organs, yet connected by blood vessels and nerves, and the whole traversed by tubular organs serviceable to the entire animal. The nervous system consists of a "brain" in the head, and a double, ventral nerve-cord with a ganglion in every segment, foreshadowing the nervous system in insects and other arthropods. The phylum embraces three classes: 1. Chætopoda—earthworms and marine annelids; 2. Gephyrea—marine worms, otherwise called sipunculoids; and 3. Hirudinidæ—leeches.

The earthworm or "angleworm" (that is, angler's worm, bait worm) of the "common garden variety," to use the phrase of old-fashioned encyclopedias, is a typical example of the first class, whose Latin name refers to the bristles (*setæ*) on the flattened lower surface of the body that serve the worm as "feet." A magnifying glass shows them in four double rows allowing eight to each of the rings into which the body is so plainly divided; their extremities are directed rearward, and by their means the worm pushes itself along, and is able to cling to and climb not only the walls of its burrow but vertical surfaces when not too smooth. Thus they are found frequently on roofs and in other elevated and surprising places, to which they have crawled in the night, when, as well as in warm, rainy weather, they are likely to wander a great deal. The long and greatly extensible and elastic body tapers almost equally at each end, but the head end is that which goes forward in crawling, and a lens will show a mouth on its lower surface, beneath a sort of thick lip. A long gullet leads into an expansion

called the crop, and that into a large, tough-walled stomach, beyond which an intestine leads to the last segment. The thirty-third to thirty-seventh segments are swollen, forming the "belt" (clitellum), which denotes maturity, but seems to have no special functions. The senses are few and dull. No eyes exist, nor sense of hearing, but the skin is extremely sensitive to vibrations, and to bright light, as might be expected in a nocturnal animal. The sense of taste is discriminating. The eggs are extruded in such a way as to form a glutinous ring about the body, which, when complete, is slipped over the head of the worm, and left to hatch in warm soil under a stone.

Earthworms live underground in burrows that are sunk well below the frost line. In digging they work head downward, gnawing—although they have no hard jaws—and swallowing the earth that is not easily crowded aside and then throwing it out and perhaps heaping it up as "castings." The tunnel must be wide enough to let its occupant turn around in it, and it ends in a deep chamber in which one or more worms may pass the winter without freezing. These worms naturally seek a loose, damp soil, not only for ease of working, but because moisture is a necessity, as they breathe through their skin; hence they abound in meadows and cultivated soil, and are not found on high, dry plains. During the day they lie near the surface, often with the head just protruding. Here they are discovered by sharp-eyed birds and garter snakes, and sacrificed by thousands, notwithstanding the strength with which they hang on to their retreats by the tail. When it retires to the depths of its burrow this worm plugs the mouth of the tunnel with leaves

which it draws always by the base, exhibiting considerable intelligence in manipulating the various shapes of leaves to that end.

The world-wide distribution of the earthworm is to some extent owing to man's agency. On our northwestern plains, for example, these worms originally were absent, but are now widely distributed and flourishing there, having been carried from the east, as eggs or small worms, in the soil packed about the roots of trees and shrubs transplanted to western orchards and gardens. This fact may have something to do with the recent westward spread of the robin, which, more than any other of our birds, is a hunter of them. Except where excessively numerous these worms do far more good than harm in a garden.

The naids (*Naidæ*) are small transparent worms that creep about on vegetation in fresh water, and, besides laying large eggs, they occasionally divide into two at a place in the body that appears arranged for this purpose, for it consists of a zone of very elementary tissue. "Gradually," as Minot records, "the tissue of this interpolated zone transforms itself into muscles, nerves, etc., and, growing meanwhile, it forms in front a new tailpiece to patch out the anterior half of the worm, and behind it forms a new head for the posterior half of the original body. The zone then breaks and there are now two worms." A relative, the *lumbriculus*, does the trick in a much more prosaic way, breaking in two first, and letting the separate halves acquire head or tail as best they may. This ability to reproduce lost parts is of much service in the life of the species and often of the individual, which may still live after some water tiger has bitten it in two—and

these worms are at the base of the food supply of rivers and ponds, and would soon be exterminated were they not capable of rapid and profuse multiplication.

Worms of this class dwell in great numbers and variety in the sea and in salt-water meadows and beaches, and are often beautiful as well as interesting objects of study for the visitor at the shore. The sea mouse (*Aphrodite*), for instance, which is about three inches long and of oval shape, is covered with hairlike bristles that glisten with brilliant green, red, and yellow iridescence; it is to be looked for on the mud just below the low-tide line, and inhabits both coasts of the North Atlantic. The body of the common "clay worm," dug for bait at low tide, which is olive in general tone, gleams with pearly iridescence, while its innumerable feet bear gills that are green and salmon-red. Another (*Lumbriconereis*) is known as "opal worm" for good reason; and our sands abound in slender scarlet worms of the same genus named "red thread." All these worms bury themselves in the sand, or wander through it in search of prey, for they are carnivorous, and do not hesitate to kill and eat each other. Some are fairly sedentary, and protect themselves against fishes, crabs, mollusks, and bigger annelids that seek them, by forming tubes by means in some cases of a shelly secretion, but more usually by cementing bits of shell, stones, and grains of sand into an irregular tube lining the burrow; the slender, limy serpentine tubes often seen on stones or dead shells in tide pools, are, or were, the homes of such protected worms, most commonly of the "shell worm" (*Serpula*). "Often a number of these calcareous worm tubes are seen clustered together.

When undisturbed the worm protrudes its beautiful feathered gills, which resemble a little passion flower projecting from the mouth of the tube. These gills are variously colored in different individuals, some being purplish brown, banded with white and yellow, while others are yellowish green, orange, or lemon-yellow. At the least disturbance, such as a shock or a shadow, the gills are instantly withdrawn into the stony tube, and the opening stopped by a horny disk." In the Gulf of Mexico extensive colonies of these worms often form, and as the early generations die others erect their tubes above them; as this goes on sand and shell fragments fill around and between the tubes, and after a long time the whole mass becomes a solid reddish, loose-lying rock, composed chiefly of *Serpula* tubes, which in Florida is dragged up from the beach and used as building stone.

The third class (*Hirudinidæ*) of *Annulata* is that of the leeches, those ugly, but useful, worms of land and sea. In spite of their sluglike appearance the leeches are segmented worms, although the wrinkles on their gray, mottled skins do not indicate the position of the segments beneath. The mouth on the under side of the head is armed with jaws and sharp teeth that make three or more cuts through the skin, whence the blood is sucked; there is also a holding sucker near the tail. Their attacks cause little pain, and that fact has led physicians to put them into use when bleeding is required. The eggs of leeches are laid in moist earth in little packets, and hatch in five or six weeks. The growth to maturity is slow, and continues during a long life. Many species abound in ponds and stagnant waters. Asia has terrestrial leeches, swarming in moist

vegetation; and in Ceylon the minute leeches are a terrible plague in certain regions. Many also are wholly marine. Some of the larger forms attack fishes directly, and quickly kill them by sucking their blood away; others are true parasites. On the other hand the leeches of our lakes are fed on by the white-fish and similar fishes. They are a great pest to our fresh-water turtles.

## CHAPTER VIII

### BUILDERS OF THE PEARLY SHELLS

THE mollusks, or "shellfish" (phylum Mollusca) are a homogeneous group of soft-bodied, unsegmented, typically bilateral, elaborately organized animals, mainly aquatic and marine, whose origin—probably as a derivative from a wormlike stock—is lost in the mists of geologic prehistory. In most cases the mollusks secrete from a larval gland an external shell which serves as skeleton and defensive armor; are bisexual and produce eggs, or if monœcious are never self-fertilizing. They possess a heart, and blood circulation (usually colorless); breathe in the water by means of gills, or, in the air, by a primitive kind of lung; have a nervous system and senses in some cases of a high order; the organs are normally paired, and protected by a general covering integument called the "mantle"; and the creeping species move by a muscular, elastic, ventral organ styled the "foot," while the swimmers are provided with a variety of swimming organs. Mollusks vary in size from all but microscopic minuteness to a bivalve weighing 500 pounds or a squid half as big as a right whale. They occur in all seas at all depths, abound in fresh waters both swift and stagnant, and are scattered over the earth wherever vegetation flourishes.

The phylum Mollusca is divided into five classes, as follows, and it will be noticed that four of the

names refer to the locomotive organ or "foot" (Greek *pous*, "foot") :

I. *Pelecypoda*, the Mussels—mollusks inclosed in a bivalve shell fastened by a muscular hinge, the adjacent part of the valves being generally more or less toothed; the foot is as a rule roughly comparable to the shape of an ax head.

II. *Amphineura*, the Chitons—flattened, bisymmetrical mollusks whose shell consists of eight crosswise, overlapping plates.

III. *Gastropoda*, Snails, whelks, etc.—mollusks that crawl on the flat undersurface of the body, or distensible foot.

IV. *Scaphopoda*, Tusk shells—mollusks that possess a long tubular shell open at both ends; with their small and elongated foot they are supposed to *dig* into the mud in which they live.

V. *Cephalopoda*, Cuttlefishes, and Octopods—mollusks with tentaclelike "arms" arranged about the mouth, and either an external or internal shell. These are the highest in rank.

#### THE OYSTER AND ITS RELATIVES

The lowest in rank of these classes is the *Pelecypoda*, containing the "bivalves"—mussels, clams, oysters, and the like, in which the shell is in two parts or valves hinged together over the "back" of the animal, and attached to it on each side by a powerful muscle, the "adductor," by the contraction of which the shell may be tightly shut. Within the shell the body is enveloped in a "mantle," or fleshy membrane falling like a cloak on each side; and from it is secreted the outer shell, which grows by additions to its ventral margin. These additions are in a general way annual, so that the concentric lines of growth on its exterior are an indication of the years of the mollusk's life, which is slow in growth, and long-lived. The interior of the shell is usually pearly, and marked with microscopic rugosities, which, by breaking up the light, as if by

innumerable prisms, gives the iridescence so beautiful in the pearl oyster, the fresh-water unios and many others. These pearly layers are called "nacre."

Bivalves were formerly classified in conchology as Acephala, because they have no proper head, but at the posterior end are two openings of tubes, provided with cilia. In one, the cilia induce a constant current of water which after leaving the gills brings into the animal's stomach floating microscopic food, both plants and animals, including eggs and larvæ, where it is captured and assimilated while water is ejected through the other (dorsal) pipe. This food includes bacteria, and if the mollusk lives and feeds in water polluted by sewage, or otherwise containing germs of disease, it becomes dangerous as human food; hence oysters and clams exposed to such bad conditions ought never to be sent to market because of the disease germs remaining in them.

In bivalves such as the oysters, horse mussels, piddocks, and others that are sedentary, and often fixed in place, or that, like river mussels, scallops, etc., move about freely, the mouth tubes are short; but many bivalves, as the clams, pinnas, razor fish and so forth, bury themselves in the sand of the bottom, by means of the strong distensible foot protruding from the forward end of the shell. These are provided with a double-barreled tube, called the "siphon," which may be contracted within the protection of the closed shell, or may be stretched out several inches; the animal may thus sink its body deep in the sand while its siphon reaches to the surface and inhales food-bearing water. The little squirts of water often seen jetting out of the beach at low tide as one walks along it are from clams so buried, and which, alarmed by the vibration of one's

footsteps, hastily eject the water and withdraw their siphons.

The old name for this class, Lamellibranchiata, referred to the gills, two of which, on each side, hang like curtains inside the mantle and between it and the saclike body containing the viscera; when the shell is open they are laved by the water, and extract from it, by some quality hardly understood, the oxygen necessary to regenerate the blood that flows through them; and, in addition, respiration is carried on through the skin.

The nervous system is very primitive, and the sense organs consist of an otocyst (a minute sac in which a hard particle floats in a liquid) in the foot, by which, it is believed, a sense of direction is had, and which also serves the purpose of an ear; an organ that tests the water; and in some, as the scallop, rudiments of eyes are situated on the margin of the mantle. Most pelecypods are of two sexes, but some, such as our American oysters, are hermaphrodite. Eggs in vast number, and a cloud of spermatozoa, are thrown out in midsummer, and a little of the latter succeeds in reaching and so fertilizing fortunate eggs, but almost all merely serve as food for the host of mollusks, worms, sea anemones and what not that subsist on such provender. The few fertilized larvæ drift about and happily escaping multiplied perils, presently settle to the bottom to attach themselves to some fixed object, or otherwise get a chance to grow big enough to defy ordinary enemies. Some interesting variations in this rather commonplace larval history occur, however, in certain families.

It will be possible to name only a few of the most useful or otherwise conspicuous bivalves, beginning

with the oyster, concerning which an immense amount of detailed information is accessible to the reader in the reports of the United States Government (Tenth Census, and documents issued by the Fisheries authorities) and in those of States, like Connecticut, New York, and Maryland, where oyster culture is an extensive industry, said to be worth in the aggregate about \$20,000,000. The oyster of the eastern American coast is to be found in the Gulf of St. Lawrence, but not in considerable numbers between there and western Maine, whence it is present southward to the Gulf of Mexico, except on the shifting sands of the outer beaches. It seeks protected waters and a rocky or weedy bottom furnishing objects to which it may, when young, attach itself, and later will not be torn adrift by storms, for where an oyster establishes itself in infancy it means to stay all its life. Hence the sheltered waters of Buzzards and Narragansett Bays, Long Island Sound, and the lagoons and inlets that lie behind the outer line of sandy beaches from Long Island to Florida are the sources of our supply—especially Chesapeake Bay.

A full-grown oyster will produce about 9,000,000 eggs, each being about one five-hundreth of an inch in diameter. When the little oyster (spat) is about one-eighth inch wide shells begin to form on its sides, and it settles to the bottom with its left side down, usually where other oysters are; and hence extensive colonies, or "reefs," of these mollusks form, and "rise on their dead selves" to a level where they may be reached by the oysterman's rake. Many years ago, however, it was discovered that large, marketable oysters were becoming very scarce. Oystermen therefore sought favorable

places, and raking the natural beds transplanted their catch, little and big, to new ground, where they were left to mature. This crude method was next improved on by sowing thickly over the new ground, just before spawning time in midsummer, a great quantity of empty oyster and other shells. These were favorable to the catching of "spat," and would result in a new bed that in about four years would furnish salable oysters; and annual plantings produced, after a time, an annual crop. These are the essential facts of oyster culture everywhere, although methods differ somewhat in other parts of the world—in France, for example, fascines of twigs are spread over tidal flats to catch the spat, instead of shells.

Our eastern American oysters are undoubtedly the largest and finest for the table of the many species that exist all round the globe. Those of the Pacific coast of the United States are excellent, but small; and the same is true of the European species; nor is the use of oysters abroad so general and extensive as in the United States.

The pearl-bearing oysters are somewhat distant relatives of the edible oyster (*Ostræa*), the thorny oysters (*Spondylus*), the hammer shell, the window-glass shell (*Placuna*) and others. The pearl oyster of commerce is named *Meleagrina margaritifera* and is found in scattered localities within the tropics on both continents. The chief fisheries are in the Persian Gulf, around Ceylon, in Australia, among the Sulu Islands and on the west coast of Panama. The Pearl Islands, south of Panama, yielded to the early Spanish adventurers riches in gems that rivaled those their competitors obtained from gold mines; but now they are a field of small importance.

In fact, the pearl fishery is carried on now far less in hope of a profitable collection of gems than for the profit in the shells, which have a nacreous interior of remarkable beauty—the mother-of-pearl—and the great advantage of offering this in almost flat surfaces, sometimes eight or nine inches broad, making it useful in the arts as well as in the more practical line of buttons, knife handles, etc. Sometimes the whole surface of a fine shell has been carved, cameowise, with cunning art and an exquisite effect.

## CHAPTER IX

### BUILDERS OF THE PEARLY SHELLS

—*Continued*

#### MUSSELS, SCALLOPS AND CHITONS

THE familiar marine mussels of the family Mytilidæ will some day become of great importance in this country as a food supply, as now they are useful in resisting encroachment by the sea on certain parts of the coast. They exist in vast numbers on both our coasts, and elsewhere in the world, in two genera, *Mytilus* and *Modiolus*, which differ a little in form, but not in habits. They have acquired the stationary habit, and in place of a "foot" of serviceable size have developed a gland that secretes an exceedingly tough, fibrous bunch of threads known as a "byssus," by means of which the animal may not only attach itself firmly to any sort of object, but may actually move about. The common species of *Modiolus*, the "horse mussel," lives in great numbers north of Cape Hatteras at and below the line of low water, and is much larger than the edible mussel just described. A smaller species of *Modiolus* is extremely numerous on the New England coast, and down to the Carolinas, forming dense tangled beds on muddy patches as well as among rocks, and serving to bind the mud and plants together and hold them from disintegration by stormy waves, in spite of the thin and brittle character of their shells. A southern species is bright

yellow, with dark rays; and the common modiola of the Pacific coast is dark, glossy brown. Such mussels are eaten regularly in Europe, and come to us in a pickled condition as a luxury. There is no reason why we should neglect to add our own to our long list of sea foods.

The next useful mollusk to be considered is the scallop, one of the many species of the family Pectinidæ, of which we eat only the adductor muscle. The commercial species is *Pecten irradians*, the name referring to the (nineteen) ridges that radiate from the flattened hinges to the scalloped margin of the shell, which is prettily colored. This species is common in sandy, shallow places from Cape Cod to Florida, but the fishery is most productive about the eastern end of Long Island and in Narragansett Bay. Farther north is a very much larger species (*P. islandicus*) especially abundant on the Grand Banks, off Newfoundland, where it forms an important food of the cod and other fishes. It is well known to cooks, who use it in baking their fish confections *en coquille*. A large number of other species are distributed throughout the world, one (*P. jacobæus*), inhabiting the Mediterranean having the name "pilgrim shell" in allusion to the fact that in the days of medieval religious pilgrimages, those who had visited the shrine of Saint James at Santiago de Compostela, Spain, to pay homage on July 25, were accustomed to wear a scallop shell in their hats in token of the fact—this mollusk being connected with traditions of that saint.

Turning to the fresh-water mussels, or naids, as some books call them, one is staggered to learn that more than 1,500 species have been named, a large proportion of which belong to the United States,

which is peculiarly hospitable to them because of our many rivers and lakes, together with the prevalence of limestone rocks, whose constant dissolution in water supplies the store of calcareous matter that these thick-shelled mollusks require. All belong to the family Unionidæ, in which two divisions are noted—one (*Anodon*) in which the mussel has a comparatively elongated thin shell with no “teeth” in the hinges; and the other (*Unio*) in which the shell is thick, various in shape from an oval to a triangle, and has prominent umbones, beneath which the valves (which are always alike) are hinged together by interlocking teeth embedded in a somewhat elastic gristle. The interior of all these unios is richly nacreous, and consequently pearls are produced in the same way as in the marine pearl-bearing shells; and some of the finest known gems have been derived from them, in this country and abroad, as well as innumerable specimens of moderate value. These mollusks like clear streams or lakes with a sandy bottom, and are not to be looked for in stagnant weedy waters. They keep an erect position, the ribs of the shell half buried in the sand, and move slowly about, plowing a path and dragging themselves along by means of the powerful foot, but keeping the short siphons at the other (or longer) end of the shell well above the mud.

We come next to our market clams. These are of two distinct kinds—“hard” and “soft,” or quahog and long clam, as they are distinctively called. The quahog is a thick-shelled, roundish mollusk with a distinctly heart-shaped outline when looked at end-wise. It dwells in fairly deep water, standing on its ribs half buried in the sand, like a wedge, and

moving slowly about. Young ones become the "little necks" of our summer tables.

The soft clam belongs to a different race. Its elongated shell is thin and chalky, is loosely hinged, and gapes widely at both ends, and although it is used much as food, especially in chowders, it is by no means as good as the hard clam. Its principal value, indeed, is as bait in the cod fisheries, and for this purpose enormous quantities are gathered. It lives in, rather than on, muddy beaches, sometimes in crowds of thousands, its shell deeply buried, and its long siphons reaching up to suck in water and food when the tide covers the flat. When the tide is out, a tiny hole in the sand and a spurt of water show the clammer where to dig, and his spade quickly unearths the clam.

The second class, *Amphineura*, contains the chitons and their relatives. These chitons are flattened mollusks protected by an armature of eight crosswise plates, overlapping like shingles, which creep about the rocks close to shore, and when lifted curl up like sowbugs. The most interesting thing about the chitons is the fact that they are provided with excellent visual organs, "the whole dorsal surface of some forms being studded with eyes, of which not less than 8,000 occasionally exist on a single specimen." Many of them are complete, with cornea, lens, and a pigment layer within the iris.

#### SNAILS AS TYPES OF GASTROPODS

The gastropods (*Gastropoda*), including the snails and slugs, limpets, whelks, periwinkles, sea hares and the like, are *Mollusca* having the mantle completely enveloping the body, and the shell, when present, in a single piece, and usually in spiral form.

There is a well-developed ventral foot, on which the animal creeps, and in front of it a distinct head bearing eyes and tentacles. These organs retain their normal bilaterality, but the body is, as a rule, inequilateral. The cause of this is the fact that on the animal's back is developed from the first a shell, which, with its contents, amounts to a relatively large weight, and it naturally falls over to one side. The mouth is armed with a flat, distensible, ribbon-like organ, studded with rows of chitinous teeth, that serves as a rasp and a boring instrument, and which is called an odontophore, or, in snails, a radula. Most gastropods are carnivorous.

The lowest in rank are the shell-less, or "naked" gastropods known as "sea slugs," "sea hares," and so forth. One Mediterranean species of *Aplysia* secretes a purple liquid utilized by the ancients as a dye, and this is still sought for in Portugal, where storms sometimes cast vast quantities of the mollusk on the beaches.

We come now to the great group of mollusks inhabiting fresh waters and dry land—the snails, whose group name is "pulmonates," that is, possessors of lungs, and breathing air. On the generally accepted theory that all these are descended from marine ancestors, and have gradually acquired the faculty of living on land, it would be natural to look for a series of mollusks that were amphibious, and, as it were, half-way fitted for a terrestrial existence, and such intermediates exist in all parts of the world. The little black *Melampus*, which covers the mud of tide flats on both the Atlantic and Pacific coasts in tens of thousands, and seems just as happy when the tide is out as when it is in, or when it is simply refreshed by the spray, is a good

example. A near relative, *Carychium*, is still more emancipated from the sea.

First among these pulmonates are those common in ponds and still streams the world over, of the family *Limneidæ*, called limneids or pond snails. They are in various forms. Some are limpet-shaped (*Ancylus*), some are flatly coiled (*Planorbis*), but most of them have shells drawn out into a graceful spiral; in all cases the shell is not composed of lime, but of the thin, fragile, horny substance "chitin." The best known one is *Limnea stagnalis*, which sometimes reaches a length of two inches, and inhabits almost every quiet piece of water in North America, and in Europe and all Asia except India and China.

These water snails of our ponds and ditches are exclusively vegetable feeders, and must come to the surface at frequent intervals to breathe, letting out a bubble of vitiated air, and taking in a fresh supply. Should the pond dry up in summer the limneids burrow down into the mud, and remain in that heat trance called *æstivation* until the autumnal rains refill the basin and let them come forth. The small kinds called "physas," exceedingly common everywhere in this country and Europe, differ from *Limnea* in having the shell partly enveloped in the turned-up fringed edges of the mantle, and by being coiled from right to left instead of clockwise. This reversal occasionally occurs in individuals of all gastropods, which are then said to be "sinistral," as opposed to the normal "dextral" coiling; but in the physas it is the rule.

Next come the wholly terrestrial pulmonates—snails and slugs, distinguished from the pond snails, which have only one pair of tentacles at the bases

of which the eyes are embedded in the skin, by having two pairs of "horns," one of which carries the eyes on their tips—good eyes, which may be quickly withdrawn out of harm's way by inversion of the tubular stalks. The thick, extensible foot is surmounted by a body coiled within the shell; and this foot secretes a viscid fluid that lubricates the creature's path, and often leaves a silvery trail.

Snails are mainly vegetarians. The mouth lies just under the front tentacles, and its upper lip is armed with a horny, crescentic "jaw." Within the mouth is the lingual ribbon, which may be brought up against the cutting edge of the jaw. This tongue is studded with rows of infinitesimal, flinty teeth, the radula of our big white-lipped snail, a quarter of an inch long, furnishing room for 11,000 of these denticles; and as all of them point backward the tongue easily seizes and draws into the mouth whatever the jaw nips off. Substantially the same sort of "tongue" is possessed by all the gastropods, but the arrangement and shape of the microscopic denticles is different in every species, and this is one of the "characters" used in classification. With it the carnivorous rasp away their food; and by bending it double and using it as a gimlet bandits like *Nassa*, the oyster pest, drill through other shells and devour the occupant. You may pick up on any seabeach scores of examples of the work of these borers. In Europe some kinds of slugs and snails do great damage in gardens, but we have little to complain of in this respect.

Largely dependent on moisture, the young snails that are hatched in midsummer at once seek retreats, and may be looked for under leaves, logs, and loose stones in the woods and pastures. Most

American snails are solitary, and will be found lurking in the moss beside mountain brooklets—a favorite spot for the glassy vitrinas—hiding in the crevices of rocky banks and old walls, crawling at the edge of swampy pools, creeping in and out of the crannies of bark on aged trees, or clinging to the underside of succulent leaves. Some forms, very beautiful in their ornamentation when magnified, are so minute that they might be encircled by the letter *o* in this type, yet you will soon come to perceive them amid the grains of mud adhering to the undersurface of a soaked chip or rotten log.

For fresh-water species various resorts are to be searched. Go to the torrents with rocky bottoms for the paludinas and periwinkles (*Melania*); to quiet brooks for physas and coil shells (*Planorbis*); for limneas to the reeking swamps and weedy ponds. By pulling up the weeds gently, you may get small species that otherwise easily escape your dipper or net. In the Southern States and in the tropics certain forms are to be picked off bushes and mangrove trees like fruit, especially the round “apple snails” (*Ampullaria*) as big as your fist.

#### SEA SHELLS IN NATURE AND ART

Other familiar forms of gastropods are the limpets, keyhole and half-deck; the abalones, so much used in the making of ornaments; and the many small sorts of “periwinkles” studding the rocks and hiding among the seaweeds of every coast. Then there are the pyramidal top shells (*Trochus*), the bulging, wide-mouthed turbans (*Turbo*), and the open-whorled wentletraps (*Scalaria*) which years ago were so rare that collectors paid \$100 or more for a good specimen. The two former kinds are on

sale in all seaside shops, with the natural rough brown exterior ground away until they gleam outside in the prismatic glory of the nacre layers that lie underneath. A group of heavy shells of carnivorous tropical mollusks furnishes ornaments for the mantelshelf also. These include the knobby volutes, often richly colored in marbled patterns or in spiral rows of round spots; the olives, whose ovate shells are sometimes dark purple, sometimes beautifully marked, and always glossy, because enfolded during life inside flaps of the mantle that completely protect them; the miters, that take their name from their resemblance in shape to the headdress of a bishop, and show splendid decorations in tints of red and orange; and the strong, spiny murexes, a small Mediterranean species, which is the principal source from which the ancients derived their Tyrian purple dye—a coloring matter yielded by treatment of the blood of many species, including one of the commonest little mollusks (*Purpura*) on our own coast, which old-fashioned New Englanders yet utilize sometimes for making an indelible ink for marking clothing. To this family belong the “drills” that destroy thousands of dollars worth of oysters annually in Long Island Sound by boring through them. Near relatives are the whelks (*Buccinum*), extensively eaten in England; and two of the largest and commonest shells on our eastern sand beaches, known to northern fishermen as “winkles” and along the southern coast as “conchs.” These (*Fulgur* and *Sycotypus*) are big, pear-shaped creatures with chalky white shells that crawl about near shore, seizing and devouring anything they can overcome, and working havoc on planted oyster beds; they deposit their

eggs in parchmentlike capsules shaped like gun wads and connected into a long chain that are often thrown up on the beach, where they are called sea necklaces.

Of great beauty in their rich variety of color and pattern are the tropical cone shells, of which a large number of species are known, some so rare as to bring great prices in the conchological market. Their bite is poisonous. Equally numerous in species are the charmingly decorated auger shells, some (*Pleurotoma*) spindle-shaped, others (*Terebra*) that would serve as models for a church spire. Near them is classified that white mollusk (*Natica*) whose globular shell is perhaps the commonest relic of the sea seen on our northern beaches, and sometimes is as large as a man's fist; to it belong the curious "sand saucers" to be found in August, which contain its eggs. These naticas are predatory, and burrowing their way through the loose sand come upon and devour other shellfish, boring a circular, nicely countersunk hole through their armor and feeding on its inmate; their depredations on the northern oyster beds are a serious matter.

Well known and always admired are the cowries, smooth, brightly colored shells, shaped like an olive with a gash down the length of one side. This long and narrow aperture is usually toothed, and it is only in the young that any indication of a typical spiral growth is discernible. The money cowrie of Africa is small and cream-white.

Lastly a word must be said about the largest of known gastropods, the big "conchs" or wing shells (*Strombus*), the helmet shells (*Cassis*), and the tuns (*Dolium*). They are West Indian. The species most commonly seen in the United States, form-

ing a border for flower beds in seaside villages, is *Strombus gigas*, with a delicate orange-red or pink interior, from which are cut most of the shell cameos offered to art lovers. This shell, like the great spiral triton of the South Seas, is also converted into a horn much used in foggy weather by the spongers and small coasters of Floridian and West Indian waters. The helmet shell, a heavy, rounder and smoother mollusk than the *Strombus*, is also extensively used in cameo cutting, especially the African black helmet, in which a white outer layer covers an almost black underlayer on the broad lip. *Dolium* has a large, globose but thin shell, ornamented with revolving ribs.

The class Scaphopoda is composed of a single family (Dentalidæ) known as tusk shells, because the little shells, one to two inches long, are shaped like an elephant's tusk, open at both ends. The structure of the occupant is so singular, the animal lacking head, heart, gills, and some other ordinary features, that naturalists believe it is a hopeless degenerate. One of the species of the Pacific coast is famous as the shell strung as ornaments and serving practically as money among the northwestern Indians until very recent times, under the name "hiqua."

#### NAUTILUS, DEVILFISH, AND SQUID

We have now arrived at the last and highest division of the Mollusca—the Cephalopoda, the class of the nautilus, ammonite, and other fossil forms, and of the squid, cuttles, and octopuses of our modern seas. The cephalopods are very different in shape, activity, and in their higher organization and intelligence, from other mollusks, but their general anatomy is the same. The special characteristic, as

indicated by the name, is the fact that the head is surrounded by tentaclelike extensions of the "foot," which is here fused in part with the head, and divided into the long "foot arms," which are the instruments by which these predatory creatures obtain their prey. The underpart of the foot forms a tube called the funnel (or siphon). Through the funnel the animal expels water from the mantle cavity, and thus propels itself through the water. When the siphon is in its normal position the animal swims backward; but it can be turned back over the edge of the mantle, giving a forward movement. In cephalopods the sexes are separate, the male being often much smaller than the female. The eggs are usually laid in gelatinous capsules, commonly known in New England as "sea grapes," and the development is direct, that is, without any free-swimming larval stage.

The class is divided into two subclasses: 1. *Tetrabranchiata*, cephalopods with four plumelike gills inside the mantle; and 2. *Dibranchiata*, with only two such gills. In the first subclass belong all those very ancient cephalopods called in a general way ammonites, goniatites, orthoceratites, etc., that are found in such great numbers and astonishing variety in the Paleozoic rocks, from the Ordovician age onward, although but few groups survived beyond the Carboniferous period, and only two families can be traced as high as the Tertiary deposits, one of which—that of the nautilus—survives to the present day as the final remnant of one of the conspicuous and interesting populations of the primitive ocean.

The pearly or chambered nautilus is one of several species inhabiting the East Indies and the coral

region of the South Pacific seas, creeping along the bottom in deep water, most numerous at the depth of about 1,000 feet. Hence the animal is not often taken alive, although the smoothly coiled and handsome shells are cast on the beaches in great numbers; and little is known of its habits or embryology. It is a soft lumpish sort of creature, with a great number of short arms and tentacles around the mouth, none armed with suckers. It begins life as a mere globule covered by a minute hood of shell; but presently, growing too large for this hood, it enlarges it by additions to the rim, and then forms behind its body a partition (septum) across the shell, cutting off the part in which it was born. As growth advances, this enlarging and partitioning continues until the nautilus has attained its full size. Then, as before, it occupies only the outermost chamber, behind which the whole interior of the shell is divided by the septa into chambers, abandoned and empty, but filled with a gas that buoys it up in the water. Oriental artists are fond of grinding away the dull exterior of the shell and exposing the gleaming nacre underneath; and of carving in this mother-of-pearl picturesque designs, examples of which are often to be seen in curiosity shops. This is not only the last remnant of the great group of ancient nautiloids, but one of the smallest, for some of the Paleozoic coiled forms were as big as a washtub, and the straight ones were often six feet long.

The Dibranchiata, on the other hand, are comparatively modern, as their ancestry dates back only to the Trias, and our seas still harbor a long list of living representatives. This subclass has two divisions: 1. Octopoda—octopods, the eight-

armed argonaut and other octopuses; and 2. Decapoda—decapods, the ten-armed cuttlefishes, or calamaries, and the squids.

The octopods have a saclike body with eight arms of about equal size, in some kinds thick and short, in others long and snaky. Every arm has along its underside a double row of round, muscular suckers without horny rims; and whatever is seized by



THE CHAMBERED NAUTILUS—SECTION

H, Head. T, Tentacles. E, Eye. M, Muscles. S, Shell.  
A, Air Chambers

one or more of these arms is drawn into the mouth at their base, where it is bitten by a beaklike jaw of sharp horn, and further devoured by means of a toothed tongue similar to the radula of gastropods. Nearly all are tropical, but some species exist in deep water considerably to the northward. Certain species are used as food in many parts of the world, and are considered a delicacy in Italy and other

Mediterranean countries. The fishermen of Japan and the Philippines capture them by the simple process of lowering big earthen urns and leaving them on the bottom overnight; when they are hauled up in the morning many will contain entrapped devil-fish, as sailors call them, which at once go to market.

A very singular octopod is the little argonaut, or "paper sailor." Its body is not larger than a walnut—that is the body of the female, for the male is only a tenth of that bigness. Its home is mainly in the tropics and in deep water, but in the summer spawning season it rises to the surface, and is occasionally met with far northward on the Gulf Stream, drifting, apparently, in a snug little boat. The two dorsal arms are expanded into broad, roundish membranes at their ends, and old stories said that they were used as sails—a supposition of much use to poets; but the "boat," shaped somewhat like the shell of the nautilus, is not a shell proper, but a membranous pouch secreted by the mantle in spawning time, and not vitally attached to the body, but held in place beneath it by the two broadened arms, and serving as a receptacle for eggs and a cradle for the embryos hatching from them.

Turning now to the Decapoda, we treat of things much nearer home and familiar on both sides of the continent, for these are the cuttlefish and squids, none of which have an external shell, but possess an interior brace to their muscles either of lime or of chitin. The cuttlefish proper, or calamaries, are those of the family Sepiadæ, which have an oval, flattened body bordered by a fin; and two of the ten arms are, in the female, in the form of long, slender tentacles. In addition to being edible and easy to get, as they stay near shore, their calcareous back

brace is the "cuttlebone" fed to cage birds; and they furnish the substance from which the drawing ink called "sepia" is made—principally in Rome. This is a brownish black liquid that the animal jets out through its siphon when it thinks itself in danger in order to make an inky cloud in the water behind which, as a sort of smoke screen, it may run and hide. Other cephalopods use this means of escape.

The squids, however, are all elongated in shape, and have finlike expansions of the mantle only on the tail. Two of their arms are long and slender, and are broadened at the tips, and studded with suckers. These suckers in some squids are strengthened by a horny rim, or by recurved hooks, or by both. The eyes are large, perfectly formed, and as serviceable as those of the fishes on which they prey. These, and some other animals, including small ones of their own kind, they capture by darting backward, swinging quickly to one side and seizing the victim in their sucker-bearing arms. They themselves are devoured by whales, seals, and many kinds of fishes; and enormous quantities of squids of various species are annually collected by fishermen for use as bait in the Newfoundland fisheries. In place of the calcareous cuttlebone of the sepia the squids have their bodies stiffened by an internal strip of chitinous substance called the "pen."

Squids are of all sizes from an inch to twelve feet in length; then there is a surprising jump to the giants (*Architeuthis*) of the North Atlantic, which, when the tentacles are stretched out in front, may measure seventy-five feet from tip to tail. These are little different in structure or habits from their smaller brethren that exist in so many species near all coasts and throughout the midseas right around

the globe; but their huge size makes them fit antagonists of the sperm whale, which hunts them, and whose hide often bears a record, left by their powerful suckers, to show how hardly some big squid struggled for life. These monsters are the greatest invertebrates known in present or past time; and it is probable that the long wriggling arms of one and another, glimpsed at the surface, may account for some of the sea serpent stories brought home by apparently perfectly honest sailors, especially those which in many cases recount that the supposed "serpent" was in conflict with a whale. Carcasses of these gigantic squids are occasionally cast on the shores of Labrador and Greenland.

## CHAPTER X

### ANIMALS WITH JOINTED FRAMES

**T**HE phylum Arthropoda embraces an immense assemblage of small animals, inhabiting salt and fresh waters, the land, and the air above it. The typical members of this group have a body divided into segments, jointed limbs, some of which are modified into jaws, and a more or less firm external skeleton. The general organization is complex, with the nervous system and senses well developed, in some divisions showing powers of perception and brainwork of a very high order. The chief divisions, or classes, of the Arthropoda are given below in the order of rank, from those simplest in organization to the most complex. Members of the first three classes breathe by gills, and are termed Branchiata, the remainder are air breathers or Tracheata.

*Crustacea*—Crabs, lobsters, shrimps, barnacles, beach fleas.

*Trilobita*—Trilobites; eurypterids (fossil only).

*Xiphosura*—Horseshoe crabs.

*Onychophora*—Peripatus.

*Myriapoda*—Centipedes; millipedes.

*Arachnoidea*—Spiders, mites, ticks, scorpions.

*Insecta*—Insects.

As several of these classes contain many subdivisions, and thousands or even tens of thousands of species, all that is possible is to give the reader such an account of each important group, as will

enable him to assign to their proper place such arthropods as he may encounter in his rambles, or in his reading, and to learn something of the manner of life in the various groups.

#### CRABS AND THEIR SMALL RELATIVES

"Everyone," says Dr. Calman, "has some acquaintance with the animals that are grouped by naturalists under the name Crustacea. The edible crabs, lobsters, prawns, and shrimps are at least superficially familiar, either as brought to the table, or as displayed in the fishmonger's. . . . Many, however, will be surprised that the barnacles coating the rocks on the seashore, the sand hoppers of the beach, and the wood lice of our gardens, are members of the same class. Still less is it suspected that the living species of the group number many thousands, presenting strange diversities of structure and habit, and playing an important part in the general economy of nature."

The great majority of crustaceans are aquatic animals, breathing by gills or by the general surface of the body, having two pairs of "feelers," or antennæ, on the front part of the head, and at least three pairs of jaws. Most crustaceans are hatched from eggs, usually in a form very different from their parents; and they reach the adult state only after passing through a series of transformations quite as remarkable as those that a caterpillar undergoes in becoming a butterfly. All crustaceans, except a few much modified land forms, breathe by means of feathery or platelike gills which are always an appendage of the legs, where they appear as one or more lobes. Colorless blood propelled by the heart wanders into spaces in these lobes, and there lies

separated from the water by a mere film of tissue, through which oxygen is absorbed from the water. Most crustaceans are covered, at least in part, by some sort of shelly coat composed of a combination of the horny substance "chitin" with lime, which reaches its highest state in the big lobsters and crabs. This not only protects and gives support to the internal organs, but also to the muscles by which the animal moves. In other words it plays the part of a skeleton. As it does not increase in size after it is once formed, and cannot stretch much, the crab must cast its shell at intervals as it grows. The new covering, which had been formed underneath the old, before molting, is at first quite soft, and the animal rapidly increases in size owing to the absorption of water. The shell then gradually hardens by the deposition of lime salt.

The reader who may not hitherto have understood the difference between "hard" and "soft-shelled" crabs is now instructed; and it is observable that the figurative expression "a hard-shell," when applied to a man, signifies that he must undergo a complete change before his ideas will be enlarged.

The simplest of the crustaceans are those small creatures of the subclass Branchiopoda (gill-footed) that swarm in our waters, both salt and fresh. Lakes, ponds and ditches abound in a variety of minute or even microscopic species that, in gathering food from equally small bits of dead organic matter, as well as from living plants and animalcules, perform an important service as scavengers—a service, in fact, performed by all crustaceans in a greater degree than by any other single group of animals. They also furnish the basis of food for the whole body of aquatic life, since it is upon these

minute crustaceans that fish fry, tadpoles, insect larvæ, caddis flies, and so on, must mainly depend. One of them is *Daphnia*, familiar to keepers of aquariums. Another is *Cyclops*, a favorite with microscopists and abundant in stagnant ponds, which is a member of the group called copepods that form an important part of the oceanic plankton, where they are the chief consumers of the minute algæ; but they also occur at all depths. In arctic waters the copepods are so abundant that they form the principal part of the food of certain fishes and of the whalebone whales. These, and their minute relatives, the ostracods, produce a large part of the phosphorescence of the sea, and some of them exhibit bright colors.

All these are free swimmers, but nearly related to them are the barnacles (*Cirripedia*) whose larvæ float about for a time near shore, and then settle down and attach themselves by their hinder parts to a rock or some other support, and begin to secrete an armature of limy overlapping plates that forms a strong cup in which they sit, often in a crowd that whitens a big rock. When the tide is low these sessile "acorn shells" are tightly closed, but when the water returns, bringing its load of invisible food, the animal stands up, as it were, and thrusting out its feathery legs sweeps the water to capture a meal—a beautiful sight to watch. The relation of the plates in the barnacle's cup to those in the coat of the higher Crustacea is more easily seen in the more pelagic "goose barnacle," whose hinder part is extended into a tough, flexible stalk, while the fore part is covered by plates. This kind is fond of attaching itself to floating timber, to ships' bottoms, or even to the surface of whales,

and thus floats or is carried all over the watery globe. To it belongs the ridiculous myth of the barnacle geese.

Great numbers of crustaceans of more advanced types live in the open sea, and at all depths; and many of them assume extraordinary shapes. The space between tide marks, and the mud of salt marshes and tidal creeks abound in a wide variety of species, some of which are familiar to everyone who lives at or visits the seashore. Thus the sand and rows of drifted seaweed on all our eastern beaches are likely to harbor flocks of amphipods, well called "sea fleas" or "sand hoppers," which sometimes jump away before you in hundreds as you walk along.

Here, too, are to be found the pretty, burrowing "mole crabs," or "ivory crabs," so called from their shining white jackets; and a host of other species with strange forms and habits haunt the margins of tropical and Oriental seas. All these are bandits, preying on whatever they can catch, and between times guarding themselves from capture by fishes, bigger crabs, and other enemies, by lying in mud burrows, to the bottom of which they are quick to retreat. The big arm of the fiddler crab, held across its face, closes its burrow like a door. One sort, the hermit crab, has all its hinder parts naked, and so backs into an empty snail shell, curling its tail-like soft abdomen around the central column of the shell and so dragging it about with it, with its armored head and thorax sticking out of the mouth of the shell. As it grows it becomes too large for its first shell, and from time to time must leave it and find a larger tenement in which to ensconce itself—a perilous transfer. Let me quote

some notes I made on a New England shore to give a picture of crustacean life there in summer.

"The lady crabs were plentiful, always alert, and inclined to be pugnacious at our intrusion. The first one I met instantly rose upright at the surface of the water, and when I made an advance it sprang half way out of the water and cracked its pincer claws together as if supposing it would reach, or at any rate frighten me. Perhaps it was my shadow it clutched at so viciously. If so, the crab probably concluded its huge antagonist to be an intangible ghost upon which the most powerful claws could have no effect, for an instant later it *backed down*—literally and swiftly—to the bottom, and in a twinkling had wriggled tailwise into the mud and out of sight. When with my shovel I routed madame out of that retreat, she indignantly scuttled off too briskly to be followed, and will have great tales to tell of her adventure.

"The stone and fiddler crabs were as common and comical as usual; and I made the acquaintance of a new one called *Gebia*, which was a small, semi-transparent, bluish white, washed-out, bloodless specimen, shaped somewhat like a crawfish and carrying bunches of roe beneath its abdomen. It looked like a miniature lobster made of glass and filled with milk. Then in the eelgrass there was a funny isopod, called *Caprella*. It was half an inch or so long, and clung by its hinder feet to the grass, waving its body up and down in search of minute prey. Other isopods and amphipods were exposed by turning over stones or digging in the sand at the edge of the water—small, pale, shapeless crustacea, which are flattened laterally so that they must lie on their sides, and when uncovered will kick

about with feet and tail in laughable anxiety to get under something. Under the stones we found the tubes made by a certain species; and when we captured the active little architect and put him in a bucket of clean water, he instantly began to gather grains of sand and stone and to join them together into a shield under which he might hide. We found that these grains were joined together by spider-like threads, which the amphipod spins from two pairs of small legs under the middle of his body, secreting a fluid that hardens in the water. Another (Hippa) about the size and shape of a robin's egg, but with a thin shell of mother-of-pearl (so to speak), gave us great amusement by its extraordinary celerity in burrowing, so that we could hardly seize it before it had squirmed down out of reach into the wet sand."

The edible crabs (*Cancer*) live in the shallow region just below ebb tide, for they cannot endure exposure to air as well as other species, and live by scavenging. The lobsters are inhabitants of still deeper water, especially where it is somewhat rocky, and devour more carrion than living fish. That miniature of the lobster, the fresh-water crawfish, which is also edible, dwells in deep burrows in wet lands—burrows that are really wells half filled with water. Various species of these and other edible forms of Crustacea are found all over the world.

#### MILLIPEDES AND CENTIPEDES

The myriapods (class *Myriapoda*) are those unpleasant creatures more commonly known as centipedes, millipedes, or thousand-legged worms. They have a wormlike form, with the body divided into segments, a distinct head with antennæ, jaws and

several single eyes, and a varying number of air tubes, or tracheæ; two sexes exist, and eggs are laid in the ground within cases formed by the mother of pellets of mud. They vary in size from an almost invisible minuteness to a length in some tropical species of six or more inches. The centipedes (Chilopoda) are those flattened forms so often seen in and



GIANT CENTIPEDE

(*Scolopendra gigas*).

about rotting wood and vegetation or in moist ground, their bodies looking like a chain of plates joined together by flexible skin, each section having a single pair of legs, usually very short, but in one sort (Cermatia) each leg is longer than the body, and the hinder pair twice as long, matched by two very long feelers. Most of them are predacious, feeding on anything they can catch, and their strong jaws exude poison. The larger ones may inflict a very painful bite if incautiously handled.

Another group, the Diploda, are known as galley worms, or millipedes, and have two pairs of bristle-like legs on each segment. Here the body is as round as that of an earthworm, and is incased in a

hard, chitinous shell, usually red-brown in color; and when disturbed they coil up and emit an acrid, unpleasant odor as a defense.

#### WEAVERS OF SILKEN TRAPS

The class Arachnida, which contains the scorpions, spiders, mites and their allies, connects the Crustacea with the Insects; and some naturalists include within it the eurypterids and king crabs, classified in this book with the Crustacea. All live on land and breathe air except a small group of allies (Pycnogonida) which are marine, and may be found on the rocks, and clinging to wharf piles, etc., on our coasts as well as elsewhere; they appear to be all legs, and are known to New England fishermen as "no-body crabs." The class includes seven orders, the lowest in rank of which is that of the scorpions (Scorpionida).

Scorpions are inhabitants of warm countries, and some tropical American species are six inches in length, but those of our Southern States are smaller. They have slender bodies consisting of a cephalothorax and a long abdomen ending in a sharp sting through which two poison glands inject poison into the wound made by it, the effect of which may be very severe on a man, and is fatal to the insects and other small creatures on which scorpions prey; this "tail" with the sting is usually carried curled up over the back. The body is protected by chitinous plates above and below. The legs are four. From the head spring two great, crablike, pincer claws. When these seize an insect they hand it back to two small but powerful appendages at their base which act as jaws. Between them is a small mouth. Scorpions are nocturnal in habit, hiding by day in

crevices, and wandering about at night; thus they are likely to seek such dark retreats toward morning as a person's boots; and in hot, dry regions travelers must be cautious about examining their clothing and baggage to avoid being stung. The scorpions retain their eggs until hatched. The young when born differ little except in size from their parents, and are cared for with much solicitude by the mother, who carries them around with her for some time, hanging by their pincers to her body. The race is ancient, fossil remains occurring as early, at least, as the Carboniferous age.

The second order, Pseudoscorpionida, includes the "book scorpions," a series of minute, stingless, scorpion-shaped creatures found in moss, under the bark of trees, or more often on flies. A third order, Pedipalpida, is that of the scorpion spiders, or "whip scorpions" of the tropics; the fourth, Solpugida, contains certain ugly creatures intermediate between scorpions and spiders; and the fifth order, Phalangida, is that of the small-bodied, vastly long-legged things called "harvestmen" in England and daddy longlegs by us, which run about in the summer heat, and feed on minute insects. They abound in all the warmer parts of the world, and in great variety, South America showing some very bizarre forms. This brings us to the sixth order, Araneida—the spiders.

#### THE SPIDERS AND THEIR WEBS

Spiders are usually thought and spoken of as "insects" by the layman. Many persons call almost every creature an insect that is small and supposed to be useless, or suspected of harmfulness. But spiders are different from insects properly so called

in many important particulars of structure and habits. Spiders have four pairs of legs, while insects have six legs. The spherical abdomen, which is cut off from the head by a deep constriction, shows no segmentation, and on its floor are large glands (the arachnidium) producing the silk which is exuded from three pairs of tubes with sievelike openings, at the end of the abdomen, called the spinnerets. Their nervous system is highly developed, and they show much intelligence. Spiders are of two sexes, but the male is usually much smaller than his mate.

When egg-laying time comes the female forms a little silken bed attached to grass, or underneath a stone, or stuck to some object, or placed in a burrow, or hung like a hammock by long guy lines, and deposits in it eggs like drops of jelly. One sort places this under water, forming a nest like an inverted cup and filling it with bubbles of air, and spending much of its time in this real diving bell. A common garden spider (*Lycosa*) forms globular cocoons, and drags them around attached to the spinnerets, regardless of jars and bumps. In a large section of the tribe this is all the use that is made of the silk, which differs from that of insects (caterpillars) in being made up of a great number of finer threads laid together while soft enough to unite into one.

It is a common habit with spiders to draw out a thread behind them as they walk, and in this way they make the great quantities of threads that sometimes cover a field of grass. This is the gossamer often so annoying to us in late summer, but a thing of beauty when glistening with dew.

The gossamer of autumn, however, is made by the very small spiders of the genus *Erigones*, which

hide in the herbage, but in the fine weather that comes after the first frosts climb to the tops of posts, fences and tall weeds, in company with the young of larger kinds, and "turning their spinnerets upward allow threads to be drawn out by ascending currents of air, until sometimes the spiders are lifted off their feet and carried long distances." These are the "ballooning spiders" of which one hears. In this way the whole country is overspread with lines and tangles of trailing silken threads that whiten our clothes and stick to our faces.

Three or four hundred species of spiders might be obtained in almost any locality in this country by diligent search, and thousands of foreign species are known; hence only a few conspicuous examples may be mentioned here. The tribe may be divided according to habits into two groups of families: 1. The hunting spiders, which run on the ground or on plants, catching insects by chase or by strategy; and 2. The cobweb spiders, which make webs to catch insects, and live all the time in the web or in a nest near it.

In the former group are the Drassidæ, a family of small, varicolored spiders that run about on the ground or in bushes, one large genus of which (*Clubiana*) includes pale, or purely white species; their cocoons are baglike or tubular. The most conspicuous genus is *Misumena*, in which the species are white or brightly colored, and which spend their days among flowers, waiting in rigid attitude for an insect to alight near them on which they may pounce. Spiders can see well for four or five inches, but not much beyond that. The Attidæ are small, hairy, or scaly jumping spiders, often

brightly colored, that are found in open places and on the tops of low plants, whence they leap on their prey, or make long jumps to escape danger. To the next family, Lycosidæ, belong the large spiders most often seen in fields and pastures. They are fond of dry, sandy places, where the females live in silk-lined holes. These lycosids are long-legged, rapid runners, and capture their game by running it down. To this family belongs the famous tarantula of southern Europe, fabled to produce a madness (tarantism) in a person bitten that could be cured only by dancing to music of a certain lively measure called "tarantella." (The so-called "tarantula" of our southwestern desert region, is, however, another species.) A common northern spider (*Lycosa carolinensis*) is its equal in size, (the longest legs covering a spread of three inches), and in color, black with gray legs. Still larger is another North American lycosid (*Dolomedes tenebrosus*), gray with spiny legs ringed with dark and light gray, which spreads four inches.

These big ugly creatures, and the bites of spiders generally, are regarded with unnecessary dread by most persons. The jaws (mandibles) are close together at the front of the head. They are two-jointed, the basal joint stout, and the end joint or claw slender and sharp-pointed. The claw has near its point a small hole, which is the outlet of the poison gland. "The poison kills or disables the insects which are captured by the spider. Its effect on the human skin varies in different persons. Sometimes it has no effect at all; oftener it causes some soreness and itching . . . and cases have been known in which it caused serious inflammation which lasted a long time. Spiders seldom bite and

only in self-defense, the bites so commonly charged to them being often the work of other animals."

In the family Agalenidæ we meet with the first of the web makers. These are spiders of moderate size, characterized by a big head marked off from the thorax by converging grooves. Their natural home is in the grass, where their flat, closely woven sheets of silk, almost invisible by reason of their transparency, but brought into plain view when coated with dew or dust, are spread everywhere. They also are fond of getting into cellars and old buildings, and constructing webs across corners, bracketwise. Somewhere the web sinks like a narrow funnel into a short tube in which the owner hides, watching hungrily until a fly alights on his silken platform.

"The Therididæ," says Emerton, "are the builders of the loose and apparently irregular webs in the upper corners of rooms, in fences and among rocks, and between the leaves and branches of low trees and bushes. They are generally small, soft and light-colored spiders, with the abdomen large and round and the legs slender and usually without spines. . . . Most of the Therididæ live always in their webs, hanging by their feet, back downward. The webs have in some part a more closely woven space under which the spider stands." These spiders are quick to avail themselves of any chance to spin their shapeless meshes of almost invisible silk, which few regard as real "webs," in closets, cellars, and all over the house or barn. Many of them are adorned with gay colors or striking patterns, and some are much feared, especially *Latrodectus mactans*, about half an inch long, which is black with scarlet spots. It is common from

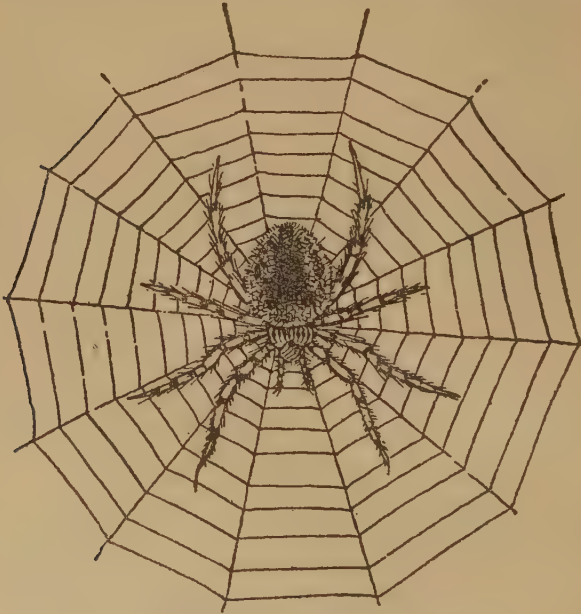
Canada to Chile, and everywhere is considered fatally poisonous—why, it is difficult to say.

Last of our list, and highest in rank, are the Epeiridæ, the “orb weavers,” as they are often called, who make those regular spiral nets which are in our mind’s eye when we think of cobwebs. Most of the moderately large and handsome house and garden spiders are of this family, and everyone can easily examine their work, although it is less easy to watch them at it, as the webs are built and repaired at night. Among the obscurer and foreign species the abdomen often shows humps, points and long forward-reaching horns that make them exceedingly grotesque, and doubtless difficult to handle by birds and other creatures that seize them as food.

One of the round webs of the Epeiridæ consists of several radiating lines, varying in different species from a dozen to seventy, crossed by two spirals—an inner spiral that begins in the center and winds outward, and an outer spiral that begins at the edge of the web and winds inward. The inner spiral is made of smooth thread, like that of the rays, to which dust will not cling; the outer spiral is made of more elastic thread which, when fresh, is covered with fine drops of sticky liquid.

“In beginning a web, after the radiating threads are finished, the spider fastens them more firmly at the center and corrects the distances between them by [inserting] several short, irregular threads, and then begins the inner spiral, with the turns at first close together and then widening . . . until they are as far apart as the spider can reach with the spinnerets [resting] on one and the front feet on the next, and so goes on nearly to the

outside of the web, where it stops abruptly. The spider usually rests a moment, and then begins, sometimes at another part of the web, the outer sticky spiral. . . . As soon as the inner spiral is found in the way a part of it is cut out, and by the time the outer spiral is finished the inner is



AMERICAN GARDEN SPIDER

(*Epeira vulgaris*)

reduced to the small and close portion near the center. . . . The whole making of the web seems to be done entirely by feeling, and is done as well in the dark as in daylight. When the spider is active and the food supply good, a fresh web is made every day, the old one being torn down and thrown away."

As a rule these orb weavers do not stay in the web in the daytime, but hide away in their nests made in some near-by but concealed place; and their egg cocoons are hidden in all sorts of places.

All of the spiders that have been considered so far belong to the division of the class that has but a single pair of lungs. A second division has been made for those having two pairs of lungs, composed of a single family, the Mygalidæ, consisting of the so-called "bird-catching" spiders and the trapdoor spiders. The great mygale of Guiana has a body sometimes two inches long, and its legs will span eight or nine inches of space. It is hairy all over, intensely black, and a terror to all small creatures, even catching small birds, according to tradition; but proof of this is wanting.

The trapdoor spiders are those of the genera *Cteniza* and *Atypus* which dig and inhabit vertical holes in the soil, lined with silk and closed at the top by a hinged stopper or "trapdoor." Several species occur in southern Europe, one of which has a second door hanging by a silken hinge half way down the shaft; and in case of trouble the spider goes below it and pushes it above its head, so that the intruder is deceived into thinking it has opened an empty nest. *Cteniza californica* is the common species of our Southwest. The cover of the hole is made of dirt fastened together with threads, and is lined, like the tube, with silk, and fastened by a thick hinge of silk. The spider holds the door shut from inside. These underground homes are safe retreats for the spiders during the day, and nesting places in which their eggs are deposited and young reared; at night the spiders go forth in search of prey.

## MITES AND TICKS

Mites and ticks are classified with the spiders as degenerate relatives of arachnoid stock. Ticks are large enough to be seen without a magnifying glass, and some become half an inch long. Ticks are wholly parasitic. The female lays several thousand eggs at one time on the ground or just beneath the surface. "The young 'seed ticks' that hatch from these in a few days soon crawl up on some near-by blade of grass, or on a bush or shrub, and wait quietly until some animal comes along. If the animal comes close enough they leave the grass or other support and cling to their new-found host." These parasites are the agents of the spread of several infectious diseases of cattle, the worst of which is the destructive Texas fever, and of mankind, as spotted fever and other ills resulting from the presence of blood parasites.

## CHAPTER XI

### FROM BUTTERFLIES TO BEETLES AND BEES

THE generally accepted classification of the insects divides them into more than twenty orders, and these into hundreds of families whose species, already catalogued, are three times as numerous as all other known animals together. "There are, for example," as Lutz remarks, "15,000 species of insects to be found within fifty miles of New York City; more than 2,000 of these are either moths or butterflies."

Insects as a class are characterized primarily by the division of the body, when adult, into three clearly defined regions—the head, the thorax or fore body, and the abdomen or hind body. All insects have three pairs of legs, distinguishing them from the eight-legged spiders, and from the many-footed myriapods and other arthropods, and most of them have one or two pairs of wings, borne like the legs on the thorax, the abdomen never bearing either. The head consists of four segments, but in most cases the first three are consolidated into the hindmost, and are represented only by the appendages they bear. The foremost of these are the mouth organs, of which there are three pairs: the most anterior are the mandibles, next the maxillæ, and then the labium, the two latter bearing articulated prolongations known respectively

as maxillar and labial palpi. The mouth has an upper lip (labrum) and contains a tongue. These mouth parts are variously modified, and by these modifications insects may be classified in two groups: "First, those in which the jaws and maxillæ are free, adapted for biting, as in the



A FLORIDA KATYDID  
(*Cyrtophyllus floridensis*)

locust or grasshopper; and second, those in which the jaws and maxillæ are more or less modified to suck up or lap up liquid food, as in the butterfly, bee, and bug." It is in this latter group that we find those having those interesting relations with plants that result in cross-fertilization of flowers.

From the forehead spring a pair of antennæ, which are not only "feelers," but the bearers of other senses. They are jointed, and exceedingly

various in form and service. Some are mere stubs, others long and slender as a whiplash, or they may be thickened at the end, as commonly in butterflies, or bear rows of hairs on each side, giving them in some cases a beautiful plumelike appearance. With their antennæ insects inspect by touch whatever they come in contact with, and test the shape of what they may be constructing, such as cells for their eggs. They recognize one another, and apparently exchange communications, or become aware of a stranger, and the ants induce their captive aphids to let down the honeydew by stroking them with their antennæ; but in many of these cases, if not all, additional information is derived through the antennæ by reason of the senses of hearing and of smell which many of them certainly possess. Ears, or organs sensitive to vibrations, and delicate hairs and other processes connected with nerves responding to touch are found in various other parts of insects' bodies, but the feelers are preeminently the seat of the sense of smell.

The eyes of insects are of two kinds, simple and compound. The simple eyes are small and practically useless single ones (ocelli) situated in a triangle of three on the top of the head. The compound eyes are on the side of the head, and are covered by a transparent layer of the chitinous skin (cornea), divided by delicate lines into square areas (facets). Beneath each facet of the cornea is an "ommatidium," optically separated from its neighbors by black pigment, and consisting of an outer segment or "vitreous body" and an inner segment or "retinula" formed of sensory cells. In some such eyes the ommatidia are few, but in others extremely numerous, so that the eyes cover a large

space; some hawk moths are said to have 27,000 facets. The nature of the picture conveyed to the mind by such an eye has aroused much discussion. Photographs taken through the eye of a dragon fly show that, though the eye is compounded of many lenses and sensitive areas (retinulæ) corresponding to them, yet the whole eye throws one image on the retina. However complex such an eye may be, it is devoid of any focusing arrangement and can only receive a clear image when the retina and the object are separated by the focal length of the lenses. Hence the need for active movement on the part of creatures having them.

The head is connected with the thorax by a neck often protected by the overlapping front of the "tergum," or chitinous plate that covers the thorax. The thorax consists of three segments, named from the front backward "prothorax," "mesothorax," and "metathorax." These and a few other technical terms are in such constant use in describing insects that it is important to know them. The under (ventral) surface of the thorax is protected by another plate named "sternum." The armor is not continuous all around the body as in the crustaceans, but that on the upper surface is connected with the sternum by a seam of soft skin along the sides of the body.

Each segment of the thorax bears a pair of legs, each of which consists of a stout, flattened "coxa," nearest the body; a small second part, the "trochanter"; a third, the "femur"; a fourth, the "tibia"; and finally the "tarsus," or foot, terminating in a pair of claws, bristly on their under surface to give adhesive power. It is by means of these stiff hairs, and not by any suction or sticki-

ness, that flies are able to walk on the ceiling and on vertical surfaces.

The wings of such insects as fly arise from the tergum of the thorax, and are in two pairs except in the flies, where there is but one, the hinder pair being represented by two little protuberances called "halteres." Usually the wings are strengthened by rods called "veins," and the patterns of venation vary in different groups, and form one of the means of classification.

The abdomen consists normally of ten segments, and contains most of the digestive and all of the reproductive organs, above which runs the main blood vessel, and below it the highly organized nervous system, the chief ganglion of which, in the head, is termed "brain."

The breathing of insects, although rhythmical in its inhalation and alternate exhalation, is not to the same purpose as ours. Respiration goes on by means of a system of branching tubes (tracheæ) that ramify throughout the body, and to which air is admitted through nine or more openings in the side of the body guarded by valves called "spiracles." The buzzing of flies, "singing" of mosquitoes, and the like, are sounds made in these spiracles, not by their rapid wings. At intervals the tracheæ are enormously enlarged to form air sacs. These no doubt, lighten the body, but they probably serve also to provide a reservoir of air from which the fine branches are filled by diffusion, and into which the carbon dioxide is discharged. The circulation of oxygen in adult insects, however, is never by means of the blood, but simply by absorption by the tissues into which the excessively attenuated tracheal tubes penetrate.

Insects are bisexual, and male and female are always separate individuals. Except in a few abnormal cases among the most lowly, eggs are produced and deposited in some favorable place for hatching.

#### SOME PRIMITIVE GROUPS

Insects go back in geologic history to the middle of the Paleozoic age, and their remains are numerous and much differentiated in Carboniferous rocks, when the orders Aptera, Orthoptera, Neuroptera, and Hemiptera (the last represented in the Silurian by ancestral forms of the bedbug and the cockroach—the oldest fossils yet discovered) were flourishing. The beetles and ants first appear in the Trias, the true flies, in the Jurassic, and the butterflies and moths, wasps, and bees not until the Tertiary. This indicates an evolutionary progress in structure with advancing time, as elsewhere in biology. The most primitive type (Aptera) is still with us in the skipping silver fish and snow fleas, or spring-tails, that annoy us in various situations. They are wingless, very simple in organization, and without any larval metamorphosis. Not much better are the Mayflies, or dayflies (Ephemeridæ), that sometimes in early summer arise in enormous numbers from lake shores and rivers, and then quickly disappear. Most of them live, in truth, only a single day (or night), a single one of the many American species surviving three weeks. During their brief life the female drops into water several hundred eggs where they presently hatch into swimming or crawling larvæ that next year, or perhaps not until the third spring, creep out on land, molt, and fly abroad in ephemeral crowds.

It is not a long step from these Mayflies to the dragon flies and damsel flies (Odonata), which also belong to the water spaces of the country, and are among the most interesting of all the insect tribes, and the most beautiful, as they dart and curvet over the surface of some glassy pool that reflects the steel-blue or peacock-green sheen of their long slender bodies, and the black bars that alone make their narrow and almost transparent wings visible. They are known by many ridiculous names, as "darning needles," "snake doctors," etc., but there is no harm in them; on the contrary they are to be encouraged, for they consume, especially in their larval stages in the water, a vast number of mosquitoes, gnats, and other troublesome "bugs." The adults capture their food on the wing, and are hawklike in the agility with which they turn and dodge in pursuit of their active prey. The actual catching is done with the feet, which curve far forward, and are studded with spines that give a sure grip on anything caught between them; they assist, too, in clinging to plants, but the legs are ill-adapted to walking. The wings are very powerful; are of a glassy texture, and never folded; they are crossed by a great many veins, breaking the surface into innumerable small squarish areas, and bear markings that distinguish each of the two or three hundred North American species.

Dragon flies, and their cousins, the smaller and more graceful, low-flying damsel flies, pair as a rule in flight. In some of the families the female descends below the surface of the water, and is able by special apparatus to insert her eggs beneath the skin of a plant; others place them in plant stems above the water, or simply drop them at the

surface, whence they sink to the bottom. The "nymphs," as aquatic larvæ like this, with incomplete metamorphosis, are termed, go about preying on anything they can seize and eat, and possess some very peculiar temporary adaptations to their under-water career. After a time the nymph (which is the "dragon" in dragon fly) changes from a rather slender to a broad and flattened creature and crawls out of the water. Soon its skin splits, and an adult dragon fly emerges.

Closely allied to the dragon flies are the stone flies, or alder flies (Percoptera), whose ugly and predacious nymphs are so well known to anglers as "dobsons," "crawlers," and by many other local and opprobrious names, because they make excellent bait for still-water fishing. The adult is that great, thin-winged creature called "hellgrammite" (*Corydalis cornuta*), with a wing spread of four inches, and possessed in the female of powerful biting jaws, which, as in all insects, work horizontally and not up and down as among vertebrates. In the male the jaws are extended into long, curved, piercing organs which cross when at rest, and which are fully an inch in length, but fortunately they are not used as jaws, but for holding.

Related to these is a group of well-known insects belonging to the old order Neuroptera, but now placed in separate orders, all with lacelike wings and an incomplete metamorphosis. They include the ant lions, the useful aphid lions, the scorpion flies (Panorpa), the lovely lace-winged flies, and the caddis flies, which make larval cases of bits of stick, or of shells or fragments of stone, in the bottoms of rapid streams. From somewhere in this group, probably, the ancestral Lepidoptera branched off

to develop into the butterflies and moths of the present day. Next to them are the earwigs (Dermaptera), beetlelike insects very conspicuous in Europe, but little noticed in this country.

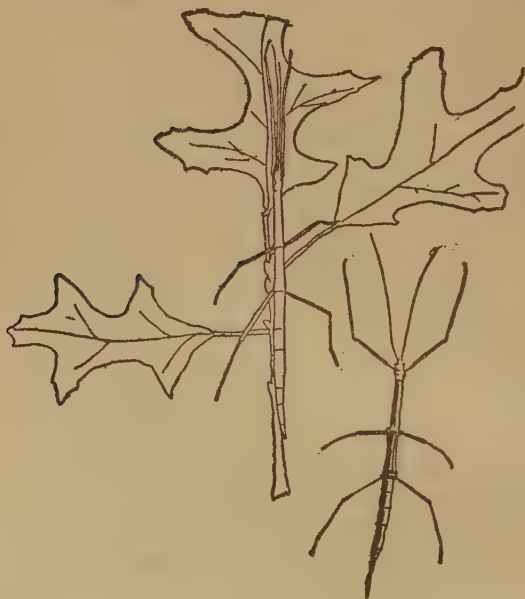
#### A MUSICAL TRIBE

Out of this confusing array of rather primitive groups we come to an extensive and well-defined order, the types of which are familiar to the most careless of observers in all parts of the world. This is the order Orthoptera, "straight wings," which includes the cockroaches, mantids, walkingsticks, grasshoppers, locusts, katydids, crickets, and their humbler kinfolk.

Cockroaches are native to all the warmer parts of the world, and we have a common large brown one, and some others of our own; but the pest of our kitchens is the small Oriental species whose origin was Asiatic, and which probably accompanied the earliest westward wanderings of mid-Asian men, and established themselves as boarders by the camp fires of the cave men. At any rate, the "black beetles," as the British call them—wrongly in both particulars—are now settled wherever ships have gone or civilized goods have been carried. As they first began to be really troublesome in New York City about the time when the Croton water was introduced (1842) they got the local name "Croton bug," but they are the world-wide *Blatta orientalis*, scampering around where they are not wanted, carrying a queer packet of eggs under the tail.

The mantids—of which a common species in the Southern States is known as "mule killers" because of the superstition that its saliva poisons stock—and the gaunt "walkingstick" insects that mimic

twigs so well that they are not seen as often as they might be, introduce us to the great tribe of grasshoppers or locusts—two words that it has worried bookmakers to keep straight. The grasshoppers fall into two families, distinguished among other points by the length of the antennæ. The short-



TWO WALKINGSTICKS  
(*Diapheromera femorata*)

norned ones (Acrididæ) are properly called locusts, and the long-horned family (Tetigonidæ) are better known as grasshoppers, despite the fact that until recently the books called this family Locustidæ. To the Acrididæ belong the locusts that in years past have worked such havoc now and then in the West, when vast swarms came from the Rocky

Mountains to the new farms along the eastern border of the plains, and ate up the young grass and crops, leaving the ground looking as if swept by fire. It is a story older than written history in all plains districts of southern Asia, Asia Minor, Egypt, and northern and south-central Africa, where no earthquake, or tornado, or other reaction of nature against man's interference with natural conditions, is so dreaded as a visitation of migratory locusts. In this country any such "plagues" as half ruined Kansas forty years or so ago need no longer be anticipated, because the plowing on ranches and other disturbance of the ground in which the locusts lay their eggs is now so extensive, and the methods of checking small flocks are so well understood, that the vast surplus generations that constituted a migration in search of food in the old days are no longer born.

All the Orthoptera are musical, or at any rate noisy, and make their rattling or piercing notes as instrumentalists, not as vocalists.

"Some species," writes Frank E. Lutz, "make a rasping sound by rubbing their hind legs against their front wings (tegmina). Others rattle, while flying, their hind wings against the tegmina. These sounds are primarily amorous serenades, and Nature's serenades without attentive ears would be even more curious than the ears for which the grasshoppers perform. In this family there is an auditory organ on each side of the first abdominal segment, just above and back of the place where the large hind femora start. Notice the clear round spot on the next grasshopper you catch. . . . Few have not heard the masculine debates as to whether Katy did or didn't, but many do not know by sight

the small, green, long-horned, stockily built disputants, both of whom usually stay high in trees. The musical apparatus of the male—the musician—is at the tegmina, and the leaflike wing covers, broadly curving entirely around the body, act as sounding boards. The female's wing covers do not have the thick rasp veins at their bases."

A third family, the Gryllidæ, contains the crickets—burrowing mole crickets, ordinary black crickets dwelling in the herbage, and several kinds of tree crickets that look like ghosts of their kind. All add to the noise of a summer evening by rubbing the roughened surface of their wing covers together—chirping to ears that are situated in the shins of the listening cricketesses.

#### THE TRUE BUGS

Skipping the white ants or termites, which are few and comparatively harmless in this country, but in the tropics make vast trouble for householders; the various sorts of lice and the little black thrips that destroys onions and some fruits, we come to the great assemblage that entomologists call "bugs," limiting the word to the order Hemiptera, which must now be considered.

The two features, basally common to all the immensely diverse members of the order, are the character of: 1. The feeding organs; and 2. The wings—in each case very distinct from that of all other insects. The bugs have highly developed piercing and sucking jaws. The mandibles and first maxillæ are transformed into stylets, often barbed toward the tip; these work to and fro within the groove of a stout-jointed beak (rostrum) which is formed by the union of the second maxillæ. The

head is usually triangular in shape, as viewed from above.

As to the second characteristic, the bugs are distinguished by the modification of the fore wings into partly horny covers for the entirely membranous hinder wings. This feature divides the order into two suborders, Homoptera and Heteroptera. In the first this hardening is little evident; but in the Heteroptera—where not wingless, as in certain families—the fore wings are stiff and lie flat on the back when closed, whereas in the Homoptera they are somewhat humped over the back, and droop down on each side a little. The triangular space marked on the back by the closed wings is a ready mark by which to recognize a hemipteran, or true bug.

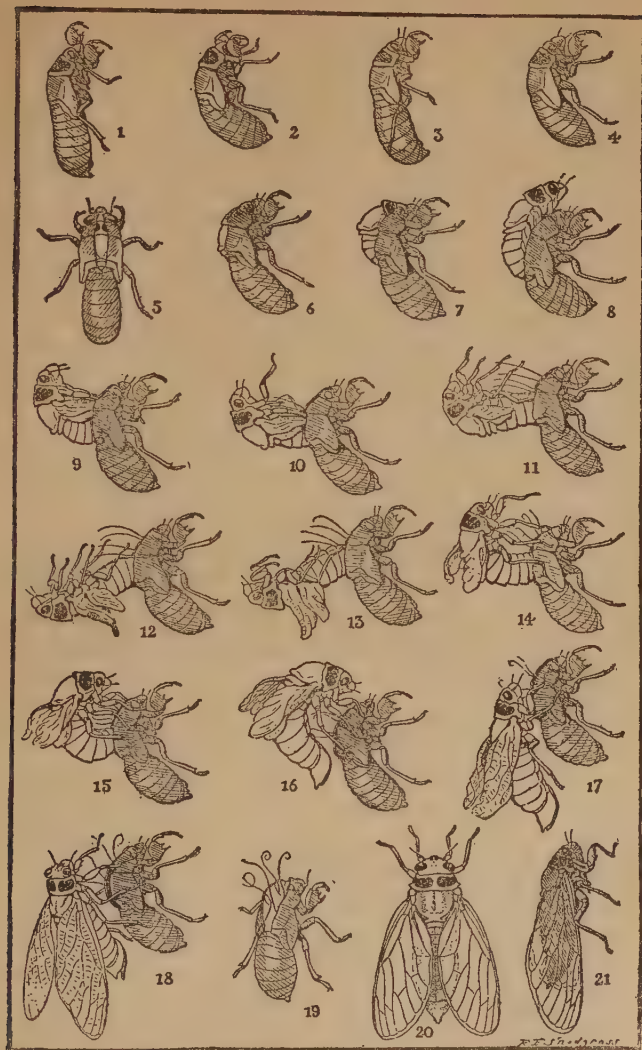
The Hemiptera display a greater diversity of form than any other order of insects, and vary in size from almost microscopic scales to fat cicadas and “giant” water bugs. “Some pass their lives in the upper parts of trees, others chiefly on the lower limbs; still others prefer the protection of roots, stones or rubbish on the ground; a large number of species select a home beneath the surface of the earth, often in the holes of ants or other insects; a conspicuous assemblage of dull-colored forms occurs only in the crevices or under the bark of trees and shrubs; while a host of others skim over the surface of placid waters, and a few are found remote from land upon the rarely disturbed waves of the tropical and subtropical oceans. . . . While the greater number derive their food either from the sap of vegetables, or the blood of fishes, animals and man, there are others which are satisfied with the strong fluid that accumulates beneath damp, decaying bark of trees, or still others which enjoy the juices of

fungi or ferns. . . . Those which creep about in search of living prey are often furnished with curved or hooked forelegs, suitable for seizing and holding creatures when in motion, such as caterpillars and other larvæ."

The Homoptera include the immense and destructive family Coccidæ, the bark lice, scale insects, and mealy bugs, among which, however, are the useful producers of lacs and such dyes as cochineal. Related to them are the Aleyrodidæ, the destructive "white flies," and the Aphidæ, almost infinite in number and in harmfulness to fruit trees and cultivated plants; also the queerly shaped leaf hoppers and similar minute, plant-sucking forms.

It is one of the curiosities of zoölogy that associated with these minutiae we find a family of bugs of large size—the cicadas, whose loud "singing" by the male in autumn gives them the name "locust," and often becomes annoying when one wants to sleep where trees are near by. The noise is made by vibrating membranes stretched over a pair of sound chambers, situated, one on each side, near the base of the abdomen. The cicada lays its eggs in slits cut in the bark. The newly hatched young drops to the ground and, burrowing into it, feeds by sucking the juices of roots. The time spent in the ground varies according to the species in various parts of the world. In the case of our "periodical" cicada it lasts about seventeen years, whence we call that species "seventeen-year locust," and know it, when a great swarm comes out of the ground and ascends the trees, by the humming of the crowd which sounds like the vibration of telegraph wires in the poles.

The Heteroptera, or proper "bugs," are a much larger assemblage, a few kinds of which have



SEVENTEEN-YEAR LOCUSTS

1-4, pupæ, increasing in age; 5-15, the locust imago struggling out of the pupa; 16, 17, 18, the imago stretching its wings; 19, empty pupa-case; 20, 21, perfect locust. (Smithsonian Institution.)

attracted popular notice. The long catalogue begins with the small "water boatmen" that live an active predatory life on the bottom of streams and ponds. Other common aquatic families are the Notonectidæ, that swim on their backs, the Nepidæ, or "water scorpions," one of whose genera is that of the slender, long-legged "skaters" that glide so swiftly across the glassy surface of still waters. Then there are the great water bugs (*Belostoma*), which all over the world are the tigers of quiet rivers and ponds, pouncing from their concealed lairs on even minnows, small frogs, and anything else they can catch and kill. These great brown bandits are sometimes two inches long. Some of the tropical species are strange in form and have extraordinary habits in caring for eggs and young.

Leaving the aquatic group, we come to certain troublesome plant-sucking bugs, and to the bedbug, which claims the longest lineage of any known insect, for the remains of perfectly recognizable ancestors are found in Ordovician rocks dating from early in the Paleozoic time. Skipping the lace bugs, red bugs, or "cotton stainers," and others, we come to a series of families that are among the worst pests of the farmer and gardener, the chinch bug, squash bug, cabbage bug and many others, the aggregate effect of whose ravages causes a loss of millions of dollars' worth of crops every year, not only in this country, but everywhere that grain, vegetables, and fruit are cultivated; and in most cases it is not the native but introduced species that does the most damage.

#### GILDED BUTTERFLIES AND DUSTY MOTHS

The butterflies and moths, whose beauty attracts more collectors than any other group of insects,

constitute the order Lepidoptera, the meaning of which term is "scaly winged," in reference to the fact that the hairs that clothe and ornament the wings are scalelike. Butterflies have club-shaped antennæ, and belong to the division Rhopalocera. Moths are Heterocera. Some of the moths, especially the males, have feathered antennæ, some threadlike, while a few tropical ones have "club" antennæ, so that this distinction is not perfect. The pupæ of butterflies are not protected by cocoons, as are those of most moths, and are usually called "chrysalides" (singular, "chrysalis"). Butterflies in general only fly during the daylight, when few moths are stirring, and usually hold their wings erect when at rest, while moths hold them flat or folded against the body.

The Lepidoptera undergo a complete larval metamorphosis, and the process is more familiar to general readers than in the case of other insects. From the eggs, which are often objects of great beauty when examined through a lens, are hatched worm-like creatures that grow rapidly by repeated moltings of the skin into full-sized "caterpillars"; those of certain moths develop in community nests, but ordinarily they live singly. All have three pairs of thoracic legs, and a variable number of temporary "prolegs" near the rear of the body. Caterpillars may be smooth, round, and colorless, or coated with a heavy fur, or bristling with knobs, tufts of hairs, and other appendages, and brightly ornamented with color; and many of these peculiarities appear to be wholly defensive in purpose. Some caterpillars give off, when alarmed, disgusting and acrid fluids, and the hairs of others irritate venomously the skin of anyone handling them, and probably account for

the fact that few birds will touch certain species. All caterpillars feed voraciously—in fact, this is the only time in the life of many species when food is taken, the adult moths and butterflies as a rule being neither willing nor able to eat. At a certain time, having completed its final molt, the caterpillar



CATERPILLAR OF THE MILKWEED BUTTERFLY

(*Anosia pleurippus*.) (Smithsonian Institution.)

arranges itself according to the custom of its race, and subsides into a pupa.

A century ago men interested in butterflies spoke of themselves as aurelians, explaining that “aurelia” was a proper name for the butterfly pupa because of the golden ornaments it usually bore. Really, however, this characteristic, so marked in the gilt “buttons” of our common milkweed butterfly, pertained to only a single family—the Nymphalidæ. When the nymphalid caterpillar reaches the turning point, it withdraws the abdomen a little from the cracking skin, exudes a little sticky silk which it fastens to its support, then hooks the tip of its abdomen firmly into this silk; this done, hanging thus by its tail, the caterpillar finally shakes off its coat and, as a chrysalis (a Greek word of the same general sense as the Latin *aurelia*): the pupa hangs, head down and inert, until the following spring.

The butterflies of greatest size and most splendid coloring belong to the family Nymphalidæ, whose hundreds of species are scattered all over the warmer parts of the world. Here belong those gorgeous tropical ones, whose wings, sometimes with a spread of five inches, emulate the prismatic hues of the "eyes" in a peacock's tail, and which are so often seen mounted as lovely ornaments in curiosity shops; and here also is classified that strange "leaf butterfly" of Malaysia, whose wings when closed so perfectly imitate a leaf of the tree on which it alights that the sharpest eyes can hardly find it. Here, too, belong our brown-streaked "fritillaries,"



FINAL MOLTING OF A NYMPHALID CATERPILLAR

(a) Before shedding skin. (b) In act of shedding skin. (c) Trying to catch hold of silk button. (Smithsonian Institution.)

such as the vanessas, and darker ones like our mourning cloak, and many others well known to amateurs.

All of this family have their chrysalides hung by the tail; but in the remainder of the butterfly families they are held in an upright position by a loop of silk that passes around them like a girdle. Such are the "coppers," the "blues," the "hair

streaks" and many other small, gayly colored species (*Lycænidæ*) common in summer, to which season they add so beautiful an interest. In another large family, the *Papilionidæ*, are found the great yellow and black "swallowtails," which are almost exclusively American, and several dark blue or purple-marked species, with "tails" to their wings, that attract the attention of the most careless as they lazily flit among the flowers. In this family, too, are the sulphur-yellow butterflies that dance over the roads and fields in little flocks; and, alas, the white ones whose caterpillars are so injurious to cabbages and similar vegetables. The last family (*Hesperidæ*) contains small, rather obscurely marked, butterflies that connect the *Rhopalocera* with the *Heterocera*, or moths.

In fact the distinction between the two divisions of *Lepidoptera* is one of convenience rather than of science, for it marks difference of habits rather than of structure. Instead of a naked pupa, that of the moth is inclosed in some sort of envelope called a "cocoon." This may be an earthen cell underground, or a woolly tuft fastened to some such support as the bark of a tree, or a leaf rolled and tied by silken threads into a tube, or a burrow in dead wood, or a paperlike case fastened to a twig; but in every case some special provision is made for the easy emergence of the imago when the time comes for its birth as a moth. The moths themselves do no harm. Their few weeks of life are devoted entirely to mating and putting their eggs in just those places where the larvæ they will never see can have the food proper for them and the best chance for life—a matter of marvelous instincts and adaptations. Few of them, except the hawk moths, eat at



Photo, A. N. Mirzaoff

CATERPILLAR BEGINNING ITS COCOON



MOTH AND EGGS

Photo, A. N. Mirzoeff

all. That is done in the caterpillar stage, when many sorts become destructive of the labor and hopes of the farmer and gardener and orchardist, or make havoc in stores of grain and meal, and in garments of wool and fur, carpets, and cabinets of natural history specimens.

Most of the moths are small, inconspicuous, grayish or brownish creatures whose markings, very lovely when closely examined, so closely resemble in their mottlings the places where the moths rest during the day, that they are comparatively safe from the birds, monkeys and other enemies that seek to catch and eat them. Some, however, are of large size and brighter hue. Thus the silkworm moths of the Orient (and of our own land) may measure four or five inches across the outstretched wings, as does the cecropia and others that flit about evening lights; and a near relative among us is the exquisite, long-tailed, luna moth, which is pale green with chestnut edgings; many others in this group are almost as "richy bedight" as butterflies. It is these that make the large papery cocoons so easily seen in the fall in trees and bushes.

A remarkable family (Bombycidæ) is that of the hawk moths, which much resemble in shape and action humming birds. They are day flyers, but most active in the morning and evening twilights, and hover on whirring wings before a flower, while with their long, tubular tongues they suck its nectar, for these moths feed as well as do their fat, uprearing, bulldoglike caterpillars, to which they owe another common name for the family—that of sphinx moths. Their pupæ are lodged under, on, or near the ground in a loose cocoon, and are to be

recognized by an appendage, curled around like a jug handle, in which lies the chrysalis' long tongue.

#### FLIES AND THEIR HYGIENIC IMPORTANCE

Flies, scientifically speaking, are only those insects of the order of *Diptera*, distinguished by having only one pair of fully developed wings. They pass through a complete metamorphosis, and the larva is in all cases a "grub" or "maggot" destitute of legs. It is rarely enclosed in a cocoon but lies buried in the ground, floats in the water, or is protected by the last larval skin which, separating from the pupa skin, remains around it as a hard case. Flies and their larvæ live in the most diverse manner. Some flies attack backboned animals and suck their blood, some prey on smaller insects, some suck honey, and some find their food in decaying animal and vegetable matter. A large number of dipterous larvæ eat refuse, many feed inside growing vegetable tissues, and some prey, or are parasitic, on other insects. More than 10,000 species of true flies have already been named in the United States alone. The order contains all the different species and varieties of fleas, mosquitoes, sand flies, gnats, midges and gall flies. Then come the blood-sucking gadflies, and half a dozen families allied to them; the scavenging syrphus flies, the bots that trouble cattle, the house flies and stable flies of deservedly bad repute; and, lastly, the horseflies, bee parasites, and botflies. The popular interest in these insects is confined to the flies of our houses and stables, and to the mosquitoes. In fact it is in the relation that the flies mentioned, and some others, bear to public health and comfort, that this group of insects is important at all to any but the special student.

## BEETLES AND THEIR GRUBS

The beetles (order Coleoptera) make up a very distinct and natural group of insects, characterized by the horny or leathery texture of their forewings, or "elytra," which serve as cases for the folding membranous hind wings alone used in flight. These elytra, when closed, usually cover the whole hind body. They are strengthened with ridges around their edges, and marked with a series of longitudinal furrows and often also with impressed dots. The hind wings are sometimes very small or wanting; in such cases the elytra are often fused together along their middle edges (suture). The head is usually extended from behind forward, having therefore a large crown and a small face; the feelers are very inconstant in form; the mandibles are always developed as strong biting jaws; the prothorax is free and movable; its tergite (pronotum) is a very prominent feature in all beetles, reaching back to the origin of the elytra.

The beetles undergo a complete metamorphosis, and the larvæ, called "grubs," have various shapes, while the pupa is "free," that is, closely similar in development and appearance to the adult. Beetles are world-wide in distribution and more than 100,000 species have been catalogued. They are divided into a great number of families, among which those mentioned below contain the most noteworthy forms.

The tiger beetles are large-headed, predacious forms, most numerous in the tropics, which live in holes in the soil and rush out to seize passing prey. The ground beetles (Carabidæ) are a very extensive family, represented in all parts of the world, and are

insect hunters, destroying hosts of injurious insects. Most of them are black or brown. The Dyticidæ and Hydrophilidæ are aquatic families, including some of the largest and fiercest of carnivorous beetles, the terrors of ponds and marshes, where they prey not only on other insects and their young, but on tadpoles, small fishes, etc.; and their grubs are quite as savage. The rove beetles (Staphylinidæ) are a very large family of narrow, elongated species, which are very active; they feed mostly on small insects, worms and snails. The carrion beetles belong to the family Silphidæ, the smaller among which live in moss and under tree bark, and the larger genera contain the noted "burying beetles." Some groups of very minute, ground-keeping species lead to the familiar "ladybirds" (Coccinellidæ), a large and world-wide family of small, rounded beetles, usually brightly spotted, which frequent plants of all sorts, and feed chiefly on aphids. Some quaint superstitions pertain to these pretty insects, that should be attracted rather than repelled when they visit window gardens and greenhouses, which they will endeavor to clear of the "greenfly" and similar injurious plant lice. Passing over several inconspicuous families we come to the dermestids, very small, dark-colored beetles of elliptical outline, some of whose genera are among the worst of household pests, and have been spread by commerce throughout the civilized world.

Some of the dermestids are troublesome as museum pests; others attack food in the pantry, store, or warehouse. "Drugs do not escape their attack, species devouring even cantharides and tobacco; woolen and silk goods, feathers and furs, are ruined if left long exposed to their depredations;

and one species is accused of biting young doves. . . . *Anthrenus scrophulariæ*, probably introduced into America from Europe, has received the names carpet beetle and buffalo bug, on account of its habit, both as larvæ and imago, of destroying carpets. This beetle measures about four-fifths of an inch in length, and is black, brick-red and white, the last crossing the back in two zigzag lines. The point of attack is the nailed-down edge or the lines of the seams."

Who has not been amused at the labors of the big black beetles that one meets in summer on dusty paths rolling balls of fibrous material. These "dung beetles" are the American cousin of the scarab of the ancient Egyptians, which typified to them many mystical ideas connected with life, present and eternal. With its shovellike head and broad forelegs the beetle gathers and compacts the material it wants, and begins to roll it, sometimes with the help, more often against the struggles, of another beetle toward a prepared nest-hole. Arrived there an egg may be inserted into it, and then the rounded mass is left as food for the grub to be hatched from the egg; if no egg is inserted, the ball becomes simply a mass of stored food to be eaten by its maker. Processes vary among the 7,000 or more known species of this cosmopolitan family.

Not all of this great family are dung beetles, however, or scarablike. Here belong the May bugs and June beetles that come blundering around lighted country residences in the evenings; and it is their fat white grubs that, hatched from eggs buried in the ground, devour the roots of the grass and other plants, spoiling the lawns and strawberry beds. The robin is their most effective enemy. Among the

lesser genera are those of the rose bugs, hated pests of the horticulturist and fruit grower. In that section of the family known as the cetonians are found the giants of the race, the West African "goliaths," four inches long; the tropical American Hercules beetle, exceeding six inches long, half of which belongs to the forward-reaching horn of its helmet, the South American elephant beetle which is even more bulky, and several other giants, the males of which have the head ornamented with fearsome protuberances.

Other families of beetles are the Buprestidæ, whose larvæ are injurious to trees by boring into their wood; the Elateridæ, or snap beetles, which arch their bodies and leap when they happen to fall on their backs, and among which are found the many varieties of brilliant "fireflies" for which the American tropics are famous. The larvæ of the elaters mostly live in decaying wood, and are the justly hated "wireworms" of our gardens. Then there are the Meloidæ, that include the blister beetles, or oil beetles, one of which is the cantharides of the pharmacopœia; and there are a great many more.

#### HONEY MAKERS AND PLANT STINGERS

A long shelf is required in the naturalist's library for the books relating to the Hymenoptera of America alone—our wasps, bees, ants, and their smaller relatives, which engage everybody's attention by their social habits and amazing display of instincts. Besides these three principal and familiar groups the Hymenoptera include a host of other insects of great but inconspicuous importance. In large part these are parasitic on other insects or their larvæ, or even on their eggs, and some are the most minute

insects known, virtually invisible to the unaided eye. Scarcely larger are the makers (Cynipidæ) of the galls so commonly seen on trees and plants in which they breed. Another group (Chalcidoidea) cause the swellings that disfigure plants by placing their young within their tissues, such as the "joint worms" that ruin grain; and here, again, many species are parasitic on grubs. Then there are the sawflies (Tenthredinidæ), resembling bees, whose ovipositors are like a pair of saws with which these insects are able to bore holes into wood, within which the egg is placed and the young larva burrows; of these are many and various kinds, all injurious to trees, garden shrubs and plants, each kind restricted to a particular sort of plant.

Perhaps even more numerous are the ichneumon flies, whose service in the world seems to be to keep the insect hosts down to the number possible to exist and at the same time to allow men and other animals to live. Their method of life is to deposit their eggs on or in the bodies of other insects, usually in the larval stage, where they hatch and thrive by the slow death of the host. The ichneumon flies are the dread of all other insects, most of whose adaptations for self-preservation are directed against this insidious and universal enemy to insect life.

None of the foregoing Hymenoptera live in colonies or by social methods. That plan belongs to the four most advanced divisions—wasps, bees, termites, and ants. Even among the wasps and bees, however, the larger number of species live alone or in single families, each female constructing a solitary receptacle for her purpose underground, in soft wood or otherwise. Most species store with the egg placed there half-dead insects, or pollen, etc., as

food for the grub, which receives no further attention; but a few, such as the big digger wasp (*Bembex*) take food to the grubs daily. Another class of both wasps and bees form nests of several cells containing eggs, and thus in spring families are originated by fertilized females that have survived the winter. As the larvæ develop in succession they are fed by the mother, and presently mature sufficiently to aid her in caring for the younger grubs. Out of such family nests, or "combs" of paper cells, often attached to the ceilings of sheds and porches of rural houses, have apparently developed the mutually helpful societies of bees and ants, which are often of surprising extent and permanency.

The prosperity of these social insect communities, whose instincts, habits, and products amaze us, is due to an organized division of labor in the community between three classes of "citizens"—(1) the comparatively few males, whose whole duty is to fertilize the queen mother and supply the community with progeny; (2) the selected and specially nourished "queen"; (3) a vast number of nonreproductive females, the "workers," that build and guard the nest, gather and preserve stores of food (honey), and nurse and rear the young. In some groups the duties of the workers are subdivided among classes that differ in size and equipment. It is these female workers, or their correlatives among the solitary bees and wasps, that sting, their useless ovipositors having been transformed by the addition of poison into deadly weapons by which they procure their prey, or defend themselves, or both. It is this division of labor, and attendant habits, that especially characterize the higher Hymenoptera, and give to the order the supreme rank it occupies among insects.

## CHAPTER XII

### AT THE DOORWAY OF THE "UPPER CLASSES"

#### PRIME SIGNIFICANCE OF THE NOTOCHORD

WE have been considering up to this point one of the two primary and natural divisions of the animal kingdom—that into Invertebrates and Vertebrates. Although these are terms made familiar by long usage, and refer to the absence or presence of a backbone composed of jointed sections (*vertebræ*), a truer conception of the distinction is had by regarding the first as animals whose skeleton, or frame, that gives support to the muscles and other soft parts of the body, is exterior; and the second as animals whose skeleton is interior. The one is, in scientific language, an "exoskeleton," or more or less hardened outer shell from the inner surface of which the organs grow and maintain their attachment and leverage for work or protection; and the other an "endoskeleton," around which the organs and integument are accumulated by growth, and by means of which the animal's strength is maintained, the interior bones—of which the chief is the spinal column, or backbone—giving a firm fulcrum for the operation of the muscles and a support and protection for the vital organs.

All the vertebrates are included in a single phylum—Chordata. This term has supplanted in zoölogy the old term Vertebrata (now reserved as a class

name only), because it is more comprehensive and precise. Professor Harmer says:

"The axis of the backbone of all vertebrates is formed by an elastic rod known as the 'notochord,' which lasts throughout life in some of the lowest forms, but in the higher forms appears only in the embryo. The universal occurrence of this structure has been regarded as the most important characteristic of the Vertebrata and their allies, which are accordingly grouped together in the phylum Chordata. The members of this phylum are further distinguished from other animals by several important features. Of these one of the most important appears to be the existence of lateral outgrowths of the pharynx, which unite with the skin of the neck and form a series of perforations leading to the exterior. These structures are the gill slits, and in the fishes their walls give rise to vascular folds or gills. With the assumption of a terrestrial life the higher vertebrates lost their gills as functional organs, respiration being then performed by entirely different organs, the lungs. But even in these cases, the gill slits appear in the embryo. . . . Another fundamental characteristic of the Chordata is given by the central nervous system, which lies entirely above the alimentary canal, just dorsal to the notochord. Not only does this position of the nerve centers distinguish the Chordata from the Invertebrates, but a further point of difference is found in the development."

This definition requires the inclusion of various creatures very unlike "vertebrates," and the phylum therefore embraces three subdivisions: 1. *Adelochorda*—marine wormlike creatures having a notochord in the anterior of the body, and gill slits,

both persistent; 2. Urochorda—the ascidians or tunicates, small marine creatures, some fixed along shores, others free-swimming and in some cases united into swimming colonies (e. g., the salpæ), the tadpolelike larvæ of which show a notochord in the tail; and 3. Vertebrata.

This last great subphylum is divisible into seven grand natural groups with the rank of classes, namely:

1. *Acrania*—Lancelets (*Amphioxus*).
2. *Cyclostomata*—Lampreys; hags.
3. *Pisces*—Fishes.
4. *Amphibia*—Amphibians.
5. *Reptilia*—Reptiles.
6. *Aves*—Birds.
7. *Mammalia*—Mammals.

The first of these seven classes, the Acrania, has usually, heretofore, been set apart as a subdivision equal in rank to the subphyla Adelochorda and Urochorda, and the remaining six classes were grouped into a coordinate subphylum Craniata, denoting that they alone have a distinct head (cranium); the reason was that its members, the lancelets, have no spine, but only a notochord, which, however, extends from end to end of the body above the digestive organs, and persists in the adult and throughout life. The lancelets (*amphioxus*) are small, fish-shaped creatures that burrow in the sand of the seashore, usually leaving only the head exposed, and sucking in a continuous current of water which brings with it minute food. They breathe through gill slits. The reproduction is bisexual, and by eggs.

The significance of the Acrania in this phylum is that they represent a very early ancestral stage of the stock from which the higher vertebrates (Crani-

ata) have developed, and from which they themselves, of course, have also diverged to a certain degree; and it is because they retain many primitive characteristics that the study of their life histories has engaged the attention of so many eminent zoölogists and has thrown so much light on the evolutionary history of the "higher animals," or vertebrates.

#### THE ROUNDMOUTHS—LAMPREYS AND HAGS

Popularly included among fishes, the lampreys and hags of the class Cyclostomata (roundmouths) differ from true fishes by the possession of a suctorial mouth devoid of functional jaws, by the single olfactory organ, and by the absence of lateral appendages, or paired fins. They have an eellike form and method of travel, and some species are a yard in length. They are bisexual, discharging both eggs and milt into the water to become fertilized by accidental contact. Lampreys ascend the rivers to spawn, however, and there make little heaps of pebbles, carried and piled with the mouth, in which the eggs find some protection from the many egg-eaters in all streams. Most, if not all, of the migratory parents die after spawning. From the eggs hatch larvæ that undergo a metamorphosis. Lampreys live on small crustaceans, worms, and so forth, eat carrion, and also attack living fishes. The tongue, like the interior of the mouth, is armed with teeth. They are in the habit of attaching themselves to stones in order to hold themselves against a river current, breathing meanwhile by taking water directly into the pouchlike gill chambers and expelling it, instead of sucking it through the mouth and passing it out of the gill slits. In ancient Rome the

big sea lampreys of the Mediterranean were eaten as a delicacy, and even cultivated in landlocked ponds, and they are still highly prized in some parts of Europe.

The hags are an even more primitive group of cyclostomes that live in the mud of shallow seas and are too abundant on both our coasts, where they are a pest of the fisheries. Their general habits are similar to those of lampreys, but wherever possible they attach themselves to fish on which they feed. The hag is particularly destructive to fishes caught on "set lines" of hooks, or in nets, and the loss thus resulting on the coasts of California, in Japan, and in some European fisheries is very serious. As these cyclostomes have no scales or other hard parts to be preserved except a few teeth, no fossil remains are certainly known, but it is the opinion of paleontologists that otherwise the class might be traced to the earliest Paleozoic time.

## CHAPTER XIII

### FISHES—THE ARISTOCRACY OF THE WATERS

**I**N beginning, with the fishes, an account of the typical vertebrates, it will be well to point out the structural features in which all agree. Vertebrates are bilaterally symmetrical animals, with an internal skeleton, the axis of which is composed of similar segments (vertebræ) and divides the body into a dorsal and a ventral portion. This skeleton is first formed in cartilage, and remains so, or it may become more or less hardened by deposits of lime, or completely transformed into bone. The anterior end of the vertebral column (backbone) carries a capsule (the skull) inclosing the brain. When limbs are present there are never more than two pairs. The nervous system consists of a brain and spinal cord from which trunk nerves arise and ramify throughout the body. The blood is first driven to the gills, or to the lungs, as the case may be, by means of a heart having either one or two auricles, and after it has traversed the body through arteries and veins it returns to the heart. The stomach, liver, and other viscera, lie in the ventral part of the body. The skin produces a protective covering characteristic in each division of the class, as scales for fishes, feathers for birds, and so forth.

Fishes are vertebrates fitted to live in water. Their typically fusiform shape is that best adapted

to progress through the rather dense medium they inhabit; and their limbs are swimming organs, or "fins." These are of two kinds, "paired" and "median." The former are the pectorals, one on each side of the forward part of the body, and the pelvic, or ventral fins on the belly and near together; these four serve, like the bilge keels of a ship, to maintain stability—prevent rolling over—rather than for progression. The median fin is vertical, and extends around the tail from the middle of the back to the end, when it is complete; but in most cases it is represented by an upright fin, the "dorsal" on the back, by the "caudal" fin fringing the tail, and by the "anal" fin at the vent. The powerful caudal fin is the principal agent in swimming, aided by undulatory movements of the dorsal and ventral fins; and it has a twisting action that drives the animal forward as does the rolling of the oar in "sculling" a boat. The median fins are developed from the skin, and are supported by a skeleton system of their own, not connected with the spine. In most fishes the upper and lower halves of the caudal fin are alike, and the tail is symmetrical, but in sharks and some others the end of the spine curves upward and the lower wing of the tail is much larger than the upper; in the former case the caudal fin is said to be "homocercal," and in the latter "heterocercal."

The fins of fishes are in many species modified and adapted to purposes remote from swimming or balancing. Thus it is the first dorsal fin of the remora that has become the sucker on its crown; in the angler the first rays of the back fin are lengthened and lobed to form its "lure," and elongation of various fin rays as feelers, or light

bearers, etc., may be found elsewhere. The pectorals are enormously enlarged to make wings for the flying fish and the gurnard, and to give a substitute for legs to the Oriental gobies that like to go ashore, while the ventrals are transformed in certain fishes of swift streams into organs by which they can fasten themselves to the bottom or climb against a cataract.

The skin of fishes is rather thick and tough, and abounds in glands that secrete mucus, and in cells that secrete the hardening, or protective, denticles and scales that form the coat of most species, and which differ widely.

Louis Agassiz distinguished four kinds of scales—placoid, ganoid, cycloid and ctenoid. The first named occur only in the selachians (sharks and rays) and are variously shaped particles of lime that prick through the skin, which makes excellent polishing material when prepared as “shagreen.” These “denticles” in the skin become teeth in the mouth without change of structure, and the great spurs with which the “saw” of the sawfish is armed are only extreme instances of this special adaptation.

Ganoid scales are such as formed the armor of the great extinct tribe of ganoid fishes, a remnant of which survives in our gar pikes, or billfish. In some of the fossils they are roundish, and overlap, but in modern ganoids they are rhombic in shape and plate the body edge to edge, connected by tooth-like processes that articulate with the adjacent scales, and permit flexibility in the body. The outer face of the scales is enameled, like teeth, beneath which is a layer of bone substance and the teeth in the mouth are only modified scales.

Cycloid and ctenoid scales are those of ordinary fishes, and are precisely alike, except that the hinder, or attached, end of the latter is split into a comblike fringe. They have a rounded or often polygonal form, are composed of lime, and are translucent, thin, elastic, and overlap like shingles on a roof. The scales of fishes increase in size with the animal's growth by additions to the exposed rim, and as these accessions may be observed, by counting them the age of the fish may be computed, when checked by certain other considerations.

The colors of fishes are produced by pigment cells, both in the skin and on the outside of the scales; and by a peculiar tissue composed of secretion products called "iridocytes." These, by their various ways of reflecting light, and by the color elements contained in them, give rise to the different hues of fishes.

Fish show their inferiority as a class by retaining the method of respiration by means of gills characteristic of the aquatic invertebrates. The gills are composed of bright red tassels set on hoops that encircle the throat, and are usually covered by a movable flap—the "gill cover." Under this flap, the neck of the fish is perforated by crescentic slits. The fish normally breathes by taking gulps of water into the mouth and throat, and squeezing it out through the gill slits; during its rhythmical passage over the thin gills the oxygen of the dissolved air is absorbed by the hæmoglobin of the red blood, and is carried away to incessantly revivify the body; and at the same time carbon dioxide is set free and got rid of in the outgoing stream.

An organ peculiar to fishes is the air bladder—a sac lying under the backbone and communicating

by a duct with the stomach. It is not only of service in respect to buoyancy, but is accessory to respiration. In spite of its name, however, it does not contain air, but a gas rich in oxygen and nitrogen which is secreted by certain arteries and is carried away when needed by other blood vessels, as fat and starchy substances are stored elsewhere and may be drawn upon when food falls short. Nevertheless, the chief function of the "swim bladder," which is exceedingly varied in shape, is to render the fish of the same weight as the water in which it lives. In this condition of equilibrium the fish swims with a minimum of muscular effort. A consequence of the organization, however, is to restrict the vertical range of each fish and kind of fish, because any considerable movement up or down means a change of pressure. This will bring about the expansion or contraction of the volume of gas in the air bladder and thus alter the specific gravity of the animal. Such automatic adjustment is limited, however, and practically prevents a fish rising or falling far above or below the depth to which it was born; and the fatal effects of violent change are seen in those fishes brought up in explorers' dredges from great depths, the air bladders of which are invariably so distended as to kill the animal. Nevertheless, some species seem able to migrate from and to great depths; and temperature is perhaps a greater factor in vertical distribution than the air bladder, the adjustments of which must be slow. The great body of fish life in the sea resides within about 300 fathoms of the surface.

Fishes have a brain and a system of nerves and sense organs varying according to rank, and outlining the higher developments of the nervous sys-

tem as found in mammals. Of the sense organs the most peculiar are the small sensitive bodies scattered in various parts of the skin, fins and mouth, called "end buds," each at the terminus of a nerve fibril. These buds seem to carry the sense of feeling, and are said to be represented in mammals by the taste buds in our tongues. They are aggregated in a narrow band along the side of the fish, and in a maze on the side of the head, called the "lateral line," the course of which is plainly visible on many fishes, as for example, on the sunfish of brooks and ponds. This lateral line consists of canals in the skin, opening to the surface by pores, and reached by branches of large nerves. The use of the lateral line to the fish is not well known, but it is believed that its cells are of service in balancing the body. As blind fishes are able to avoid obstacles with the greatest ease when swimming, it is possible, in the opinion of Dr. Bridge, that these organs enable their possessors to appreciate undulatory movements in the water in the shape of reflex waves from contiguous surfaces or objects.

One feature of the lateral line on the head are the "auditory organs," varying with the kinds of fish, which contain semicircular canals, with otoliths, in the more or less complete form of an internal ear. Each is reached by the auditory nerve from the brain and is also connected with the air bladder in many cases. Whether this is a true organ of hearing in the ordinary sense, or whether it serves some other purpose, as, for instance, the regulation of the distension of the air bladder, is not known. The old question of whether fishes hear sounds made above the water is not yet answered scientifically; but it is probable that they can feel the jar of sounds made in

the water, which is equivalent to hearing, as far as it goes. Fishermen have a saying that if you swear you won't catch any fish—a good precept, anyhow; but more effective is the care anglers take not to step heavily, nor to make loud, jarring noises, near the bank of the stream in which they mean to cast their lines.

The great majority of fishes have good eyesight, and the eyes themselves are similar in structure to those of the higher land animals; but it seems probable that the range of vision is short. The eyeballs are usually large in proportion to the size of the head—sometimes strikingly so—and are movable; while the situation in the head is naturally such as to give the most advantageous vision according to the habit of life. Thus those of sharks, and other predatory sorts that live by the chase, are well forward; while those of bottom-feeders, and especially rays, flatfish, anglers and the like, are in the top of the head, looking upward. Nocturnal species have the largest eyes, but the unfortunate cave fishes, whose whole life is, and has been for unnumbered generations, passed in the total darkness of caverns and underground streams, have lost the use of their eyes altogether, and the organs themselves have disappeared by atrophy.

Blindness is found also in oceanic families that dwell far below the penetration of daylight; yet many fish of the Stygian depths, which, so far as we know, never leave that region of utter blackness, possess big and apparently efficient eyes. Most of the blind or nearly blind sea fishes thus far obtained have been in hauls from a depth of about 1,200 fathoms. It is believed that the ability to see in deep-sea fishes is connected with the light-giving (phos-

phorescent) organs possessed by many of them, and with the fact that animals of all sorts on the sea bottom in deep water are luminous, and so reveal themselves to the predatory creatures that feed on them, while the fishes' own "lanterns" enable them to chase moving prey, avoid enemies, and find mates.

Fishes have efficient olfactory organs situated near the snout, and in the higher families they are in pairs and become true, but internal, nostrils. The sense of smell is strong, and perhaps more useful on the whole than the sense of sight, especially among the carnivorous species. Sharks seem to follow their prey by scent like hounds.

All these senses serve instincts related to the necessities of the individual and the race in each kind of fish. This is sometimes manifested in what appears to us as cunning means of safety or of provision for young; but discriminative intelligence is small in fishes, which probably are able to learn little more than that at certain places and times food may be had, as is illustrated in cultivated fish ponds, where the captives from infancy onward are fed regularly. Anglers tell of old trout that refuse year after year to be beguiled by their experiments in flies; but it is doubtful whether this is anything more than an increased wariness due to frequent disturbance. The remora is, or has been, used by the Caribs of the West Indies and the negroes of Zanzibar for catching sea turtles, a line being fastened to a captive and comparatively tame remora carried in the boat, and the fish turned loose as soon as a turtle is seen at the surface. The remora will make a bee line for the turtle and attach itself firmly to the shell so tenaciously that both animals may be dragged to the boat. It is to be noted that

the fishermen see the turtle near by before they dispatch their living grapple, and it is doubtful whether the remora has any notion of what it is doing. It simply obeys repeatedly an instinct. This very low degree of intelligence is doubtless owing to the almost invariable environment of piscine lives, in which virtually nothing occurs to suggest any change in traditional habits or arouse into activity any rudiments of mind a fish may possess. Mental inertness is characteristic of aquatic animals of all kinds, as contrasted with the correlated activity of body and mind of land animals stimulated by varied and changeable surroundings.

The breeding habits of fishes furnish one of the most interesting chapters in their natural history, and many surprising facts have been learned within a few years in regard to the reproduction of marine species, of great value to the sea fisheries.

In all fishes the sexes are separate. As a rule females are larger than males, and more numerous. The size of the egg in any group depends on the amount of food yolk stored for the sustenance of the young, which must thrive by its absorption until it is able to eat by its mouth. The largest are the eggs of sharks, etc. (Elasmobranchii), which resemble fowls' eggs. The European dogfish, perhaps two feet long, has eggs an inch in length, each in a flattened leathery "purse" having tendrils at the ends that twine about weeds and anchor it like a rocking cradle. The similar egg capsules of skates, dropped on the sand, are common objects on all beaches. Elasmobranch eggs are deposited at intervals throughout the year and, as they are exposed to comparatively little danger, are few in number. In most other orders spawning, as the egg laying of

fishes (and aquatic amphibians) is termed, is limited to a short period, the eggs are small, and the number of eggs produced is often enormous—five or six millions in a large cod, for example.

In the majority of Teleostomi—a group name embracing all the modern bony fishes—the eggs are voided broadcast into the water, the males at the same time emitting clouds of milt. These eggs are of two kinds, one that sinks and, often being glutinous, sticks to some object on or near the bottom, and is called “demersal”; and another that contains an oil bubble, making it so buoyant that it floats, and these latter are called “pelagic.” The fertilization of such spawn must be accidental, but as the milt and the eggs sink or drift together the number that come into fertilizing contact is no doubt considerable. Nevertheless, an extremely small percentage ever reach the point of hatching, and still fewer survive to become mature, for in addition to unfavorable circumstances of water and temperature, every living thing, almost, in the ocean, including the parent fish themselves, is a devourer of the eggs and young of fish; and it has been said that the vast number of eggs dispensed by certain species, only a single pair of which on the average survives to maturity, is one of nature’s methods of providing food for the inferior forms of marine life.

## CHAPTER XIV

### SHARKS—THE TIGERS OF THE SEA

ONLY a rapid systematic sketch of the class Pisces, fishes, is possible, distinguishing the main divisions, alluding to their history, and touching here and there the most characteristic genera and species of the thousands that have been described by ichthyologists. The primary division is into three subclasses:

1. *Elasmobranchii*—Sharks, skates, rays, etc., having a cartilaginous skeleton.
2. *Teleostomi*—Ordinary fishes, having a bony skeleton.
3. *Dipnoi*—Lepidosiren, and many extinct, primitive families.

In the *Elasmobranchii*, or selachians, the skeleton consists of cartilage, as in the embryos of all fishes—a sign of their primitive and inferior rank; but parts of it in various species become hardened by depositions of lime, especially in the vertebræ, in spines and teeth, parts often well preserved as fossils. Sharks' teeth are among the best known of fossils, and before science established their true character were commonly called "birds' tongues," or "snakes' tongues." The sharks, first to be considered, are a very ancient race, originating in early Paleozoic times. Of the many curious extinct forms that terrorized the Silurian, Devonian, and Carboniferous seas, a few representatives still exist in the South Pacific, notably the cow sharks; an eellike

Japanese species with frilled gills that Dr. Garman thought might easily fill the rôle of "sea serpent"; and the quaint bullhead, or Port Jackson sharks of Australian waters; all these are of small size and the last named represents the principal race in Mesozoic seas. Their flat teeth form a sort of pavement of the mouth, enabling them to crush the mollusks and crabs on which they chiefly feed.

Next in a rising order of classification, and of somewhat more recent origin geologically, is the European family of dogfishes (Scyllidæ), which includes also the "ground sharks" of warm seas—deep-water fish eight to twelve feet long, that creep about near the bottom in search of prey. Next come the large pelagic sharks of the family Carchariidæ, which contains about sixty species, scattered over all the seas, and one confined in the fresh water of Lake Nicaragua. One section, that of the "topes" and "hounds" of temperate and warm seas, are bottom-feeders, and have pavementlike teeth adapted to crushing and grinding the shellfish on which they subsist; but most of the family are swift and powerful hunters of fishes in the open sea, such as the dreaded tiger shark of the West Indies, which is variegated in color and sometimes twenty feet long, and the equally big blue, white, dusky, and other ferocious bandits ranging not only the tropical seas, but more common in northern oceans than is generally supposed. The teeth in these and other hunting, fish-catching sharks, are shaped somewhat like arrowheads, in some cases smooth-edged and single-pointed, in others with sharply notched edges and side cusps. They are set in the flesh of the jaw, unattached to the underlying bones, in concentric rows, one close behind the other, all round the front of the

mouth, both above and below, and look and act like a set of saws, a sidewise movement of the jaws sawing through an object seized in a single bite. As fast as the front row of teeth are lost they are replaced by those of the row immediately in the rear. But all gradations exist between these and the mosaic of "pavement" teeth in the topes. The mouth of these hunting sharks is on the underside of the head, and they must turn on their backs to seize anything floating or swimming near the surface.

This is the group that furnishes the "man-eater" stories—tales that have been substantiated by so many terrifying examples that no precaution of safety against them should be neglected, even on our northern coasts, where the ravenous blue shark, or the dusky species, may appear at any time, even in harbors. A few years ago a man was seized by one of these sharks in a little inlet of New York Bay, at Freeport, New Jersey.

Blue sharks are nocturnal in habit, and are sometimes seen asleep or resting in the daytime, with the tips of the two dorsal fins, characteristic of this family, in sight above the surface of the water. "So gentle are they in their movements," says one authority, "that, unlike many other monsters of the deep, they do not disturb the luminous creatures, which at the same time will be lighting every wavelet with their phosphorescence. Blue sharks are not very particular as to what fish they take as food, though those which are gregarious in their habits, like mackerel, pilchards, and herring, are most commonly hunted by them." A curious relative of these "man-eaters" is the hammerhead, in which the sides of the head are extended in two great lobes, with

eyes at their extremities; this kind of shark is greatly feared in the East Indian seas. In spite of it, and the prevalence of other huge and voracious sharks, the Arabs about the entrance to the Red Sea, and the natives of other Oriental shores, will swim and dive in the open sea, apparently without fear, where Europeans would be devoured almost instantly. Another peculiar shark is the thresher, well known in the North Atlantic as elsewhere for its strategic maneuvers. It grows to a length of fifteen feet, of which the tail forms at least one half. Quite inoffensive to man, the thresher feeds on the shoals of smaller teleosts, such as pilchards, herrings, and sprats. When feeding it swims in gradually diminishing circles around the shoal, splashing the water with its long tail, and keeping the victims so crowded together that they become an easy prey. Hammerheads and their relatives, the "bonnet" sharks, frequently visit both our shores in summer.

The porbeagles are big, fierce sharks of the family Lamniidæ, the giant of which is Rondelet's shark, known to attain a length of more than forty feet. The triangular, saw-edged teeth of such a one measure nearly an inch across the base; but similar fossil teeth, and also others dredged from the bottom of the South Pacific, are much larger, indicating sharks beside which Rondelet's would be small, and in all probability these monsters survived to a comparatively recent date. A remarkable lamnoid shark of Japanese deep waters has the snout produced into a long, flat, flexible, leaflike blade.

Closely related sharks, almost as big, are well known in the North Atlantic. Two of them, the "bone" and the "basking" sharks, are killed by

fishermen whenever encountered for the sake of the oil in their livers. The name of the second refers to its habit of loafing and sleeping on the surface on fine days, when a boat may go so near it that a harpoon may be planted in its hide before it will move. The real "basking shark," however, is a gigantic species of *Rhinodon*, of the Indian and South Pacific oceans, with a very bulky body that may exceed forty-five feet in length. Both of these ponderous fishes are sluggish, and are not dangerous to man, except that a blow of the tail may smash a boat when an attempt is made to harpoon them at close quarters. They feed on small fishes that go in shoals, and also, perhaps, on seaweeds.

The last sharks to be mentioned are American dogfish of the family *Squalidæ* (another family, *Scyllidæ*, are known as "dogfish" and "hounds" in Great Britain), which are numerous and greatly hated along both our northern coasts. The common gray dogfish of the North Atlantic and California coasts is the spiny one (*Squalus acanthias*), the larger females of which will weigh about eight pounds. It makes its home in deep water off the New England coast, approaching the shore when the mackerel come in and disappearing when they depart; but dogfish are to be found all summer in shoal places such as George's Bank, and irregularly in shore inlets. In the late autumn they become numerous on the Grand Banks, and stay there until the winter's cold drives them away into deeper water. Everywhere these small sharks are a nuisance to the fishermen, by tearing nets and by eating the cod, etc., hooked on the trawl lines. Formerly they were regularly hunted for the oil in their livers, which is especially valuable for certain pur-

poses, as in harness making, but the price of this oil is now low, and the fishery has declined.

The economic use of sharks is not great except as producers of oil. The flesh is good food, but not popular. In China sharks' fins are a favorite substance for delicate soups and sauces, and a very large trade in catching sharks for their fins is carried on near Bombay, and in East Indian waters.

The ugly angel shark, with its squat, toadlike body, big, winglike side fins and thick tail, occupies an intermediate place between the sharks and the rays. It creeps along the bottom, and is remarkably voracious. The chimæra is another queer "monster" of the deep.

## CHAPTER XV

### THE FEARFUL DEVILFISH AND OTHER RAYS

THE rays (order Raïæ) differ from the sharks superficially rather than in structure, where the most important difference is the position of the gill clefts, which are lateral in the sharks and ventral in the rays and skates, as the smaller members of the order are called. The majority of them have a flattened, depressed body, from which the broad, expanded pectoral fins are scarcely distinct, while the tail is usually long and slender, in one family so much so that they are known as "whip rays"; and in some a horny point at the tip is connected with a venom gland so that its pricking is poisonous, and these are called "sting rays." All the rays are carnivorous, but only the sharklike forms (sawfishes and the Rhinobatidæ) actively pursue their prey. The true rays live on the bottom and feed on shellfish and small fishes. Most of them bring forth a few young alive, but many lay eggs in squarish, oblong, leathery cases with tendrils at the corners by which they become moored to eelgrass, etc; they are frequently cast up on beaches, and go by the name of "sea purses." In the earlier stages the young ray is much like a shark, and the enormous development of the pectoral fins does not occur until nearly the time of hatching.

The sawfishes, of which several tropical species are known, besides one common in the Atlantic and



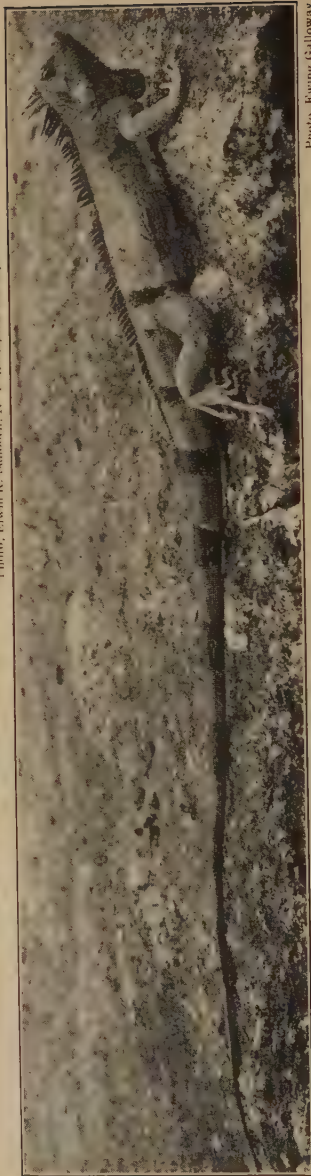
CATERPILAR PROTECTED BY FORM AND COLOR  
RESEMBLING THE TWIGS OF A TREE



SEA HORSE PROTECTED BY FORM AND COLOR  
RESEMBLING THE MARINE PLANTS AMONG WHICH  
IT LIVES



Photo, Edwin R. Silliman, N. Y. Zoological Society



Photo, Ewing Galloway

ABOVE, THE GILA MONSTER, FEARED THOUGH ITS BITE IS NOT ALWAYS DEADLY TO MAN  
BELOW, THE IGUANA, A REMARKABLE LIZARD OF THE NEW WORLD

Mediterranean, are among the most remarkable of oceanic fishes. The body is slender, sharklike, and of great power. The head is flattened, and the snout projects into a hard, flat, sword-shaped beak, the edges of which are thickly studded with sharp teeth; and this singular weapon places all the large inhabitants of the ocean at the mercy of this powerful marauder—it is the worst enemy of whales, even, in the warmer seas, as is the “killer” in the Arctic region. With it the sawfish cuts and slashes, tearing off pieces of flesh, or ripping open the abdomen of its opponent, then seizing the detached pieces. One can easily picture to himself the slaughter when a sawfish dashes into a school of fishes, squids, or porpoises, and slashes right and left with his rip-saw of a beak. Some of the Oriental species reach, and even exceed, twenty feet in length, and Dr. Day, the Indian ichthyologist, says that such monsters have been known to cut bathers completely in two. The saw of a twenty-foot fish would measure six feet in length and a foot across the base.

The most famous of the rays, probably, are the torpedos, a family with a rounded, instead of the customary triangular outline, and a rather short tail, species of which occur on all tropical and temperate coasts, and are noted for their power to give electric shocks to any living thing touching them.

The electric organs are a pair of large masses lying between the head and the pectoral fins. These are derived mainly from four nerves, which originate from an electric lobe of the medulla oblongata. By means of the electric shocks which they are able to administer at will, the torpedo rays are able to ward off the attacks of enemies, and to kill or

paralyze their prey. The action is that of a galvanic battery. The dorsal surface is positive, the ventral negative, and the discharge of a large torpedo is sufficient to temporarily disable a man; yet it is not so powerful as that from a big electric eel.

The huge "sea devils" of which thrilling stories are related are the eagle rays of the family *Myliobatidæ*, some of which are fifteen or twenty feet across the "wings"; and they are among the most frightful of the dangers to which pearl divers are exposed in their perilous occupation. They are savage beasts, and will even attack a small boat with men in it. The worst of these belong to the vicinity of Panama.

## CHAPTER XVI

### BONY FISHES—TELEOSTOMI

WE come now to the fishes proper—those with skeletons of bone, although in some of the lower forms the ossification is incomplete. The mouth contains supplementary tooth-bearing bones that form secondary jaws corresponding to the functional jaws of the higher craniates; hence the group name “Teleostomi,” or perfect-mouthed fishes. The body, as a rule, is coated with scales, and a gill cover (operculum) is always present.

The Teleostomi include four orders, the Crossopterygii, the Chondrostei, the Holostei, and the Teleostei.

The crossopterygians are mostly strange extinct fishes found as fossils from the Devonian down; but some have survived, and live in the sluggish African rivers an eellike existence, of which the bichir of the Nile is a familiar example. The Chondrostei also are largely fishes of the Paleozoic time, but two families survive to the present—the spoonbills and the sturgeons. Of the former one species is Chinese, and the other is the shovel-nosed spoonbill or paddlefish of the lower Mississippi River. It is a big, sluggish creature, that stirs up the mud with its long flat beak, and consumes it, getting sustenance from the minute organisms it contains. They make caviar from its eggs. As for the sturgeons, we have five species in the United States, and one

abounds in the Black Sea and the rivers that drain into it, from whose eggs the Russian caviar is made. One or two species are exclusively fresh-water, but most sturgeons are migratory fishes, living in the sea, but ascending rivers for spawning. Their food consists of worms, mollusks, the smaller fishes and aquatic plants; and in feeding the mouth is protruded downward in the form of a cylindrical, spout-like structure and thrust into the mud. Our common eastern-coast sturgeon is also a native of the Mediterranean and French coasts, and was formerly in England a "royal" fish, reserved to the king's use.

Of the third order, Holostei or "ganoids," whose history may be traced in fossils almost to the earliest of fossiliferous rocks, we possess in our rivers the only two survivors: one is the many-named bowfin of the Mississippi Valley, and the other the widely distributed billfish or gar pike. Both these relics of a very ancient order are of great interest to naturalists; and the names "mudfish," "John H. Grindle," and many others, show how well known the bowfin is to the farmer boys. The bowfin attains a length of about two feet and a weight of twelve pounds, and, unlike its cousins the garfishes, is covered with hard, rounded scales; the forepart of the body is cylindrical, the head stout and blunt, and the mouth filled with powerful teeth. It is exceedingly hardy, enduring absence from the water for a long time, as well as grievous injury; hence the young are the favorite bait of anglers in the Mississippi Valley, and make interesting captives in an aquarium, where, however, nothing else but snails can remain alive. These fish are strong, active, voracious and gamy. They feed on all sorts of small aquatic creatures.

The garfish (or more properly gar pike, *Lepidosteus*, because certain sea fishes of another sort are also called gars) is an elongated active fish of our rivers, covered with hard, flat, ivorylike scales set in oblique rows, and its snout is prolonged into a bill filled with sharp teeth. They have many peculiarities of structure indicating their ancient ganoid lineage; and besides our common species two others are known, one of which, the alligator gar, belongs to the Gulf Coast and Central American rivers. These gars are nocturnal and predatory in their habits, and in early summer resort in large numbers to shallows to lay their eggs, which are covered with a sticky envelope that adheres to any object on which they fall. The long bill develops after infancy.

## CHAPTER XVII

### MODERN FISHES—TELEOSTEI

THE lower orders of teleosts retain many characteristics of the Holostei, and several of their families are known only as fossils in the Cretaceous and Tertiary rocks. The most primitive survivor of these ancient forms is the great tarpon of Florida and southward, another species of which occurs in India—such wide differences in habitats being an evidence of antiquity in nearly all cases among animals. The extraordinary mormoids of northern Africa, and the eellike gymnarchus of Gambia, are other relics of the past, as also are several other queer African families, the barramundi of Australia, and the arapaima of the Amazon region. The one last named is the largest fresh-water fish known, specimens exceeding fifteen feet in length, and weighing 400 pounds, all of which is excellent food. The mother protects her offspring which, when young, swim in front of her. Several of these old-fashioned teleosts, like our bowfin and the primitive Dipneusti, make elaborate nests in which their eggs are deposited, and they and the fry are carefully guarded by the parent. In this same suborder come the most familiar and useful game and food fishes—the shad, herring, trout, salmon, whitefish, smelt, etc.

The shad family is a very large one, numbering about 200 species, most of which are marine, but

a few are "anadromous," that is, they ascend rivers of fresh water to spawn in the shallows near their sources. This is the habit of American shad, of which there is only one species in spite of the many local names in use; and it is regarded by the fisheries authorities as the most valuable river fish in the country except the Chinook salmon; but the supply of it would have been exhausted long ago had it not been for the incessant and energetic methods of replanting of fry, artificially bred, in all the eastern rivers, and the transplanting of them to rivers on the Pacific Coast, the credit for which valuable public service belongs to the United States Bureau of Fisheries.

The shad is to be found from Florida to Newfoundland. Little is known of its life in the ocean, but in spring it approaches the coast in great numbers, and may be had in the St. John's River in Florida in winter, but it is not numerous until March. It next appears in the Savannah and Edisto Rivers, and so successively northward, the height of the run in the Potomac being in April, in the Delaware early in May, and in the Miramichi River in New Brunswick late in May. The main body ascends when the water temperature is 56 degrees to 66 degrees. They come in successive schools, the males preceding the females. They ascend the rivers, often nearly to their heads, and deposit their eggs on suitable spawning grounds, pouring out about 30,000 in most cases. The eggs are very small, semibuoyant, and usually require six to ten days for hatching, depending, as does the whole operation, on favoring temperature. After the spawning the shad show hunger, and will often bite at an angler's fly.

"The herring is beyond question the most important of food fishes in the Atlantic, if not in the world," declared the late G. Brown Goode, formerly Assistant U. S. Fish Commissioner. It affords occupation for immense fleets of boats, and thousands of men, nowhere more numerous than in the North Sea and along the Norwegian coasts. Professor Huxley once gave 3,000,000,000 as the number of herring taken annually from the North Atlantic; but Dr. Goode showed that this was far too low an estimate, and added that it probably was "no greater than the number contained in a single shoal if it covers half a dozen square miles, and shoals of much greater size are on record. And . . . at one and the same time scores of shoals must be scattered through the North Sea and the North Atlantic, any one of which would go a long way toward supplying the whole of man's consumption of herring." Herrings are surface swimmers, and their food consists of the small organisms, chiefly crustaceous, which have been described as "plankton" in the early pages of this book. They themselves afford food to every predatory fish, squid, whale, and bird that frequents their region (mainly north of the fortieth parallel of latitude), and which has the wit and ability to seize them. They move here and there in shoals for food, and in spring migrate to the shallows and rivers of the northern coasts to spawn. Besides the Atlantic herring, a very similar species throngs in the North Pacific, and several others live in the Great Lakes and other waters of this country.

No fishes are better known in America than the salmon, trout, and whitefish, which are near relatives. Of the salmon there are many kinds in all

the northern parts of the world and in the open ocean. Some ascend rivers to spawn, and some do not. Our Atlantic salmon, once so abundant in every river from Connecticut northward, is the same as the salmon of Europe, and the king of game fish. Now it is at all numerous only in the Maritime Provinces of Canada, climbing the waterfalls of those mountain streams to their very springs to deposit its eggs, whence few individuals survive to return to the ocean. The heaviest salmon on record is one of eighty-three pounds captured in England in 1821; an American example of forty pounds is considered very large.

The salmon of the North Pacific are of a different genus (*Onchorhynchus*) and consist of several species, some Asiatic. On the American side we have five species, and most of them have been seen in all the rivers from central California to Alaska, Siberia and Japan; but the blueback predominates in Fraser River and in the Yukon; the silver salmon in Puget Sound; the quinnat or Chinook salmon in the Columbia and Sacramento; while the comparatively worthless dog salmon is seen everywhere. The quinnat and blueback enter and "run" the rivers in the spring, and are caught when in prime condition, whereas the other three run in the fall, and are more usually caught after deterioration; hence "spring" salmon are best in fact and in trade.

The habits of the salmon in the ocean are not easily studied, but Jordan, Evermann, and other diligent students have come to certain conclusions from a great number of facts. They believe that the king and the silver salmon probably remain not far from the rivers where they were born. The blue-

back and dog salmon probably seek deeper water. It is the prevailing impression that the salmons have some special instinct which leads them to return to spawn on the same grounds where they were hatched, but Dr. Jordan says:

"We fail to find any evidence of this. It seems more probable that the young salmon hatched in any river mostly remain in the ocean within a radius of twenty, thirty or forty miles of its mouth. These, in their movements about in the ocean, may come into contact with the cold waters of their parent river, or perhaps of any other river, at a considerable distance from shore. In the case of the quinnat and the blueback, their 'instinct' seems to lead them to ascend these fresh waters, and in a majority of cases these waters will be those in which the fishes in question were originally spawned."

As to the fate of the spawning fish, after the eggs and milt have been voided, and their duty is done, the salmon begin to float downstream tail foremost. The great majority of them die—certainly all at the headwaters of the big streams; and it is the opinion of the best judges that none ever get back from anywhere alive into the ocean after spawning, but that the race is sustained wholly by the escape of the young each year. It is supposed that none return from the sea, or attempt to ascend the rivers until at least three years old.

Trout are in most cases simply small species of salmon, and a great number of kinds inhabit the ocean, lakes, and rivers of all northern countries, for none of this great family occur in the tropics or in the southern hemisphere. Our western trout—the widely distributed and variable cutthroat, the steelhead of the northwestern coast, the beautiful rain-

bow trout of the Coast Ranges, and others are examples. The common brown "brook" trout of Great Britain belongs here; but our brook trout, the "speckled beauty" of anglers and poets, is of a slightly different kind (genus *Salvelinus*), for it is classed with the European charrs. The Dolly Varden trout of the Rocky Mountains and the Sunapee trout are also charrs. The graylings, namaycushes, and smelts are members of this family, whose final representative among us is the numerous and very valuable section of whitefish and lake herrings of the Great Lakes and Canada generally.

No family of fish is of more importance as food for man, not to speak of the sport many of its members afford, than this; yet, doubtless, it would have been nearly destroyed by this time had it not been for the intelligent and patient work of fish culturists and the farsightedness of governments, both Federal and State, and Canadian, in supporting and extending economic replenishing of depleted waters. The organization and breeding habits of the salmon tribe lend themselves to this work.

Passing by some families of deep-sea fishes, of small size and most bizarre outlines, we come to the suborder that contains the carps, catfishes and "minnows" of our lakes and streams. Here, the first to present itself, in the large family Characinidæ, is that fierce little brute of South American rivers, the "piranha" or "caribe," of which Col. Theodore Roosevelt had so much to say in describing his explorations in Brazil in 1913 and 1914. One of his companions was Leo E. Miller, who has since published another account and increases the bad reputation of the caribe by what he has to tell of its ferocity:

"In the Orinoco they attain a weight exceeding three pounds, and are formidable indeed. The natives will not go in bathing except in very shallow water, and I know of two instances where men were attacked and severely bitten before they could escape. The fish somewhat resembles a bass in shape, although the mouth is smaller; the jaws are armed with triangular, razor-edged teeth; and as they travel in immense shoals they are capable of easily devouring a man or large animal if caught in deep water. . . . Usually they are slow to attack unless their appetite has been whetted by a taste of blood from a wound; then, however, their work is done with lightninglike quickness. . . . To catch them we used a large hook secured to a long wire leader and baited with any kind of raw meat, and they always put up a good fight."

A related fish in the Rio La Plata is almost equally dreaded because of its much greater size and formidable teeth, but it works singly; and Africa has many similar characinids, whose flesh is good food, though full of bones. In this order, too, is now classified the family of the "electric eels" (*Gymnotidæ*) which are not, however, eels, but merely long, cylindrical fishes, naked and almost finless. The well-known one of the Amazon region grows to a length of eight feet and the thickness of a man's thigh, and is justly feared. It is found only in marshes and in comparatively shallow parts of rivers, to the annoyance of travelers who have to ford at such points, beasts of burden being frequently knocked down by the electric shocks. About four-fifths of the length of the fish is occupied by the tail, which contains the electric organ. This consists of two huge masses filled with a jellylike sub-

stance, below the spine, and separated by a narrow median septum. This apparatus is under the control of the fish, which by it may stun or kill an enemy or an intended prey, even at a considerable distance.

The family of the cyprinids—the carp, goldfish, chubs, shiners, loaches, and other “minnows” of this and other countries—contains about 1,300 species, scattered over the whole world except South America, Madagascar, and Australasia. All are freshwater fishes, feeding on vegetation and small animals; and they vary in size from two or three inches to a six-foot carp—the original home of which, now the cosmopolitan giant of the family, was Asia.

Next to these are placed another extensive freshwater family, that of the catfishes (*Siluridæ*). More than 1,000 species, mostly tropical, have been described; these are grouped in eight subfamilies, among which there is a wide diversity in shape and habits—in fact, few of those of foreign lands look at all like the catfishes with which we are familiar in America. Most of them are sluggish, but some actively inhabit swift streams. They can exist not only in foul water, but will live a long time out of this element, and some even make long migrations overland from river to river. One or more fin rays are sharp and poisonous in many species, as boys know who handle the little bullhead incautiously, and an African species is able to administer a strong electric shock. Its apparatus is not a battery of modified muscular tissue, as in other electric fishes, but consists of a thick coat of greasy material surrounding the whole body just beneath the skin. Another general characteristic is the protection and assiduous care given to their eggs and young, most species making some sort of a nest in

which the eggs are deposited and the fry kept safe from attack.

The third suborder of teleosts contains eellike fishes of the tropics; and the fourth contains the true eels and their relatives. Our common eel is also "common" in most of the temperate countries of the world, but there are perhaps 150 other species of the family *Anguillidæ*, a large proportion of which live altogether in the sea, many of them at great depths, and showing strange shapes. The generation of the eel was, until recent years, one of the great mysteries of zoölogy, as no propagation, or any symptoms of it, ever appear in fresh water. Finally it was discovered that a queer, almost transparent, compressed creature, a fraction of an inch long that abounded in the surface waters of the ocean, and which had been a puzzle to naturalists, who called it *Leptocephalus*, was the larva of some sort of eel. This and other discoveries made it plain that when the eels (of the age of four or five years) leave the rivers and bays of all countries and coasts in the autumn, and go out to sea, they do so to spawn, leaving their eggs on the floor of the ocean, mostly south of Bermuda, according to J. Schmidt. From them hatch the minute larvæ that, as they grow, rise to the surface, and when about a year old appear as the silvery young, called "elvers," that drift on the northward-running currents to the coasts of Europe and North America, and ascend the streams by millions in spring. It is not probable that any of the adult eels that go down to the sea to spawn ever come back; and if any remain in landlocked waters whence they cannot migrate to the salt water, they do not breed; but it must be remembered that eels are able to travel a considerable

distance overland, at night, from one piece of water to another, and so many may finally reach the sea.

The next suborder illustrates the remarkable difference in size and external appearance that often marks fishes grouped together by similarity of structure. It includes the muskellunge and all the other pikes and pickerels, and the tiny shiners and "bait minnows" of our rivers and brooks, and those of the Old World, one of which is the smallest fish known; it includes several families of deep-sea fishes, often of quaint form and with curious appendages; here, too, is the valuable blackfish of Alaska, the amphibious, phosphorescent little fish of Indian bays and estuaries which when salted and dried forms the Oriental delicacy called "Bombay duck"; and here are the blind fishes of the Mammoth and other American caves. The Heteromi and Cateosteomi are almost equally miscellaneous assemblages, the most notable members of the latter being the funny little pipefishes and sea horses that lurk in the eelgrass near shore, and the males of which carry the eggs and young about in a pouch on the belly. In the next suborder, Perceosces, we find more strange denizens of the mid-oceanic depths, especially the family Chiasmodontidæ, besides some surface ones of ancient lineage, such as the gar and snakeheads of tropical waters, the flying fish and the mullets. The Anacanthini is a small group containing the remarkable pelagic and abyssal macrurids, the fierce barracudas, and the most valuable single family of food fishes in the whole list—the cods.

The cod family (Gadidæ) has many species in northern seas and a few south of the equator. It includes, besides the cods, the haddock, hake, whiting, coalfish, capelin, ling, and several other market

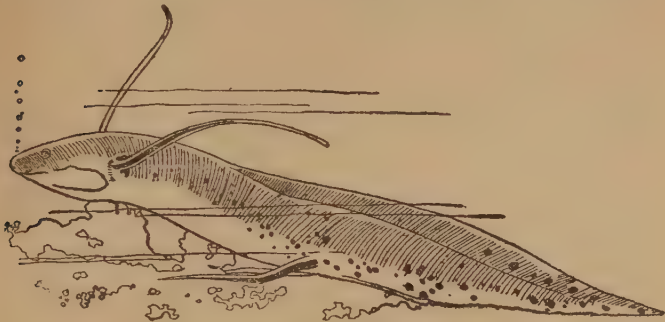
fish of importance. The cod is a deep-water fish which goes about in great schools whose movements are not well understood, but in winter they approach the northern shores of the continent, seeking shallows on which to spawn, and it is then on the "banks," off New England and Newfoundland, that the most profitable fisheries are followed. The cod is extraordinarily prolific, and in addition to this it is propagated artificially more extensively than any other fish.

Thus we come to the last suborder, Acanthopterygii, or "spiny-finned" fishes, in which are classified the greater number of really modern and more or less familiar swimmers in the "briny deep." Among American members are the sunfishes and black bass, the perches and darters; the great family (Serranidæ) of sea bass, snappers and West Indian groupers; the tilefish, which appears and disappears in a puzzling fashion; the grunting drums and their relatives of the Scienidæ; the porgies, sheepshead, and other Sparidæ; the brilliantly colored angel fish of the coral reefs of Bermuda and southward; the surf fishes, so important in California; the wrasses, parrot fish, and globefishes, or boxfishes, that inflate their horny hides when alarmed, until they bob about on the surface like corks.

#### FISHES WITH PRIMITIVE LUNGS

There remains the fourth subclass — Dipnoi or Dipneusti, the lungfishes. The reason why these creatures, whose organization is on an antique and lowly plane, judged by fish standards, have been elevated to subclass rank is that here the air bladder is modified into a single or double elongated sac with many cellular spaces, and is connected by a short

tube with the mouth, and thus serves as a lung. The peculiar structure of the heart, narial openings, and the power of existing for a considerable period out of water, are extremely amphibianlike, and they have by various naturalists been regarded as scaly sirens—a sort of connecting link between the fishes



AN AFRICAN LUNGFISH

(*Protopterus annectens*)

and the amphibians. They are found fossil in Paleozoic rocks, especially in the Old Red Sandstone of Great Britain, and also in the Upper Jurassic strata in Colorado.

The surviving species (family Lepidosirenidæ) are widely scattered, as is characteristic of all these very ancient families. A celebrated example is the barramundi of Queensland—an elongated, flat-sided fish, covered, except on the head, with large roundish scales, and having paired fins that look more like flippers than fins. It becomes four or five feet long. It lives in still pools in which the water in the dry season becomes extremely stagnant and overladen with decomposing vegetable matter; and it is only by rising to the surface occasionally, and taking air into its lung, that it is enabled to obtain sufficient

oxygen for purposes of respiration. The barramundi does not leave the water, nor can it live long in the air. It is easily captured, and is eaten by the blackfellows.

Equatorial Africa possesses three species of the genus *Protopterus*, which dwell in marshes, and feed voraciously on young fishes, frogs, and small animals. The form is somewhat eellike, and the paired fins are soft, slender appendages of little use, locomotion being effected by the powerful tail. Like the barramundi this fish rises at intervals to take a breath of air; its "lungs" are double, while that of the barramundi is single. In the dry time of summer the *protopterus* burrows deeply into the mud of the dried-up marshes, where it curls up with its head highest and subsists wholly by breathing air until the autumnal rains bring water enough to enable it to wake up and resume its aquatic life. A similar eellike species abounds in the swamps, sluggish rivers and marshes of northern South America, named *Lepidosiren*, and all its habits closely resemble those of the African lungfishes.

## CHAPTER XVIII

### AMPHIBIANS—A CONNECTING LINK

WE have now come to a class of vertebrates that in their manner of life, and presumably in their history, connect the dwellers in the waters with those on the lands of the globe. Dr. Gamble cites examples from various groups of animals to show that adaptation to a terrestrial existence is an advance on that requisite for aquatic life, and that the critical point in the evolution of the vertebrate phylum was passed when its members migrated from water to land. "When we come to land animals," he says, "the problem of weight has to be considered before that of locomotion. The lateral undulations of the body, even when aided by unjointed paddles, or fins, are not sufficient to insure rapid movement on land. Hence a system of levers has to be evolved, partly to support the body, and partly to propel it. The use of joints becomes a necessity, and we find that all active terrestrial animals, except snakes, have jointed limbs. The critical point in the history of this phylum is passed when its members migrated from water to the land. The step was taken by the ancestors of the Amphibia (that is, the frogs, toads, and salamanders). In them the breast fins of the fish have become the jointed forelegs, the pelvic fins have become the hind legs."

How this great change from the fish fin to the five-fingered hand occurred is, at present, just as

obscure as the mode of conversion of the arms of reptiles into the wings of birds. The answer can only be supplied by further discoveries in the geological history of the order, and though this history can be traced back to the time of the Coal Measures, we find the earliest Amphibia as sharply marked off from the fishes by their feet as they are to-day. These forefathers (subclass Stegocephalia) are the earliest known four-footed animals, and their fossil skeletons are found from the Carboniferous up to the Trias, after which the race disappears. They had the general form of newts, and many were only a few inches in length. That some of these, at least, were terrestrial in habit is shown by the fact that they are often found in stumps and hollow logs of sigillarias and other fossil trees of the coal beds, especially in Nova Scotia. But there were also species several feet in length, with formidable teeth, which were no doubt carnivorous and predatory, so that it was well for the little ones to seek places of safety. These stegocephalians were unmistakably amphibians, with two condyles supporting the skull, but their skeleton contains many features that suggest reptilian anatomy, and it is agreed that the reptiles sprang from this stock. The peculiar feature of this group is that their flattish heads were covered by a broad shield of bony plates (ossified skin); and similar armor protected their bellies, and in a few cases the back also.

Geological formations furnish no ancestral connection between the Stegocephalia and modern salamanders; but the limbless, wormlike, burrowing and blind cæcilians of the tropics exhibit certain stegocephalian characteristics, especially a scaly skin, which put them into a division (Apoda) by

themselves. The remainder of the class, that is, Amphibia (also called Batrachia) in general, have a soft, moist, naked skin, and are naturally divisible into two orders:

1. *Urodela*—Tailed amphibians: newts and salamanders.
2. *Anura*—Tailless amphibians: frogs and toads.

Modern amphibians in general are animals fitted for life both on land and in water. All are born from eggs hatched in water, and the young, at first in a larval form unlike the adult condition, have external gills adapted to breathing in that element; but in most cases they lose their gills, and as adults acquire lungs for breathing air. This metamorphosis of the young, comparable to that of the nymph-producing insects, is the especial characteristic of the class. The skeleton is of the vertebrate model, but in the *Urodela* is largely cartilaginous. The skin is smooth, soft, moist, and covered only with a filmy coat of horny texture that is molted from time to time as the animal needs room to grow. The skin abounds in sense organs about the head and along the sides of the body—an inheritance from the lateral line of fishes—which are most active in the larvæ, and disappear altogether with age in most frogs and toads, although they revive in salamanders in the breeding season.

The skin also contains many mucus glands and other larger glands, especially on the back. These emit under provocation a poisonous liquid that is fatal to small animals, and very irritating to the eyes, nose, and throat of larger ones. Most, if not all, Amphibia, says Dr. Gadow, are more or less poisonous, and it is significant that many of the most poisonous exhibit a very conspicuous yellow.

or orange upon a dark ground, which is so widespread a sign of poison. There is no venom in their bite—in fact, their teeth are too small, although numerous, to let anyone fear their biting. The skin is heavily laden with pigment, and this is displayed in many amphibians in striking patterns of bright coloring. Certain groups possess in a high degree the power of altering their colors to conform to their surroundings.

An interesting feature of the amphibians is that power of repairing mutilations of the body and replacing lost parts which is so well known in worms, hydroids, and other lowly creatures, and is termed “regeneration.” This ability is most active in young specimens. Tadpoles frequently have their tails bitten off, whereupon new ones grow quickly. Salamanders fight bitterly, tearing off each other’s gills and limbs, and turtles and fishes frequently bite off their tails. New tails are generated speedily, and usually in good and effective form, although they contain no regenerated caudal vertebræ, but only a rod of cartilage. The ability to rebuild lost parts is much less among the frogs.

Another notable fact is that here for the first time we meet with a voice organ, and a real voice expressing emotions, although in an extremely limited way. This is most noticeable in the tree frogs, which are the most advanced of the Amphibia in organization.

#### NEWTS AND SALAMANDERS

The Urodela are represented throughout the whole northern hemisphere except in desert regions, as far in North America as southern Canada, and also southward to Panama; and in the Old World, north-

ward to the line of very cold winters and southward to the Mediterranean and Indo-China. In the main, however, our genera are different from those of Europe and Asia.

The largest and best known of American urodeles is a member of the family Proteidæ and genus *Necturus*, and is widely known as "water dog" or "mud puppy," because of the doglike shape of its head. It is a brown, robust creature, sometimes two feet long, with bushy gills, retained throughout its life, springing from open gill clefts in three bright red tufts on each side of the head. It inhabits cold, rapid streams, hiding under stones by day, and moving about at night in search of crawfish, worms, insect larvæ, frogs, etc., and dodging hungry snapping turtles. But little smaller, and even more ugly in appearance, is the "hellbender," representing the family *Amphiumidæ*. These blackish creatures are to be found in mountainous regions, and hide during the day under loose rocks. By the time they are about three years old their gills have been absorbed, and their lungs are in service, so that they are compelled to rise to the surface occasionally for drafts of air. They hunt at night for food, preferring crawfish and, fishermen say, fish eggs. The breeding habits of this animal have only lately become known, and Mr. B. G. Smith, who has made a special investigation of them, says that the breeding season begins (in Pennsylvania) in August, when hellbenders of both sexes come out more freely from their rock shelters and roam about, frequently in small companies. The small number of eggs produced are hidden in a pocket under a loose stone; and the young, which are more like tadpoles than the form of their parents, breathe by gills which do not

completely disappear until the animals have reached nearly their maturity.

Otherwise our salamanders are small species found in brooks, ponds, and wet woods, and often getting into cellars and wells. Uninformed persons think them to be lizards, and foolishly fear them, but except for the irritation of the hands that may follow rough handling they are utterly harmless to man or his property, and serve him by devouring great quantities of insects and worms.

A common species in damp, neglected woodlands is the little red-backed fellow that is so light and leaping in its movements when disturbed, even throwing off its tail in its panic of fear. It is more terrestrial than most, laying its few eggs in rotting wood instead of going into the water for that purpose; and the young carry gills but a few days. This red-backed *Plethodon* must not be confused with the small newts, bright vermilion with a row of glowing spots along the sides, that are found in woods in summer. They are young specimens of *Diemyctylus viridescens*, which is common all over the eastern part of the United States and southern Ontario. The parents are green, and wholly aquatic in habits. The larvæ have gills and swim about until early autumn, by which time their gills have been gradually absorbed, and they go ashore, where their coats change in color from a mottled green to scarlet. This red condition and their residence on land continue until the autumn of the third, or the spring of the fourth year of their lives, when they become sexually mature, resume a greenish dress, go back to the water, and pass the rest of their lives there.

Mention can be made of only one more species—the black, yellow-spotted “tiger triton,” which is the

most widely spread and often seen of our terrestrial salamanders. It is especially noteworthy because of the extraordinary condition of suspended development exhibited by its larva, the famous edible axolotl of Mexican lakes, which, while still retaining larval gills and aquatic habits, grows nearly or quite to the size of its parents—three to four inches—and becomes capable of breeding. Similar cases are known in certain lakes in southern Europe; and it appears that this arrested development, together with natural growth of body, occurs occasionally in many other amphibians. The condition is termed “neotomy,” but the biological explanation of it is not clear.

## CHAPTER XIX

### AMPHIBIANS—*Continued*

#### FROGS, TOADS AND TADPOLES

THE frogs and toads of the order Anura differ from the inferior batrachians principally in form. The tail is absent, and instead of long, slender bodies and small legs, or none, they have short, squat, triangular bodies and hind legs, at least, of relatively great size and strength, whereby they progress when on land by leaps instead of by running or creeping; some are almost wholly aquatic in habit, others almost wholly terrestrial or arboreal. The ossification of the bones is far more complete, the eyes and ears (represented by the large tightly drawn membrane, the "tympanum," on each side of the head, covering the internal ear) are well developed, and the voice is louder than in the urodeles, which can do little more than squeak. The mouth is usually large and cleft to beyond the eyes. The tongue, used to capture prey, is not thrust straight forward, but thrown "overhand," as it were, catching the insect aimed at in its curling and sticky tip.

All frogs and toads are flesh eaters, mainly of worms and insects and larval or small water animals; but the big species, such as the bullfrog, may seize prey of considerable size as it comes within reach, such as young ducklings. None hunt about for prey, but, aided by the concealing nature of their colors, wait quietly until a victim comes within reach

of their quick and accurate tongues. All lay their eggs in still water, varying in number from a few score to several thousands, according to the species. In all cases the young are hatched in a larval form, called "tadpole," having a tail and gills, and this gradually changes into the adult, tailless form of the adult. On emerging from the egg the embryo has a very large head and body. In a frog the external gills and the long, compressed tail are only feebly developed when the tadpole is first hatched, while the mouth is provided with a much developed adhesive apparatus, by means of which the young attach themselves to plants or other objects. The tadpole changes by regular stages into the adult form, the tail being slowly absorbed into the body from which the legs grow out.

The Anura are separable into two suborders:

1. *Aglossa*—Having no tongue.
2. *Phaneroglossa*—Possessed of a tongue.

The *Aglossa* are few in number, and belong to southern Africa and tropical America, where the group is represented by the famous Surinam toad, whose eggs are fixed in separate pits or "pouches" in the spongy skin of the mother's back, where they are placed as fast as laid, by aid of the male.

The *Phaneroglossa* contains several families, the first of which, *Discoglossidæ*, is characterized by the round, nonprotrusible tongue, and includes species of toads belonging mainly to the Mediterranean region, two of which are familiar to most readers of natural histories.

It may be well to say at this point that the terms "toad" and "frog" do not express scientific distinctions, although generally applied by naturalists to

the first three families of the list, and especially to the Bufonidæ; but mark the facts of popular observation that the members of these families are more terrestrial than the members of the families that follow them, and that they have rough warty skins in place of smooth and shiny ones; but many exceptions confuse both the classification and the use of the words—as, for example, in the case of the hylas, which you may call either “tree frogs” or “tree toads,” according to your liking.

The two species mentioned above are the “unke,” or firebellied toad of Germany, which when alarmed displays its scarlet underparts by a peculiar attitude calculated to surprise and frighten away an enemy. The other is the “midwife toad,” most common in Spain and Portugal.

The spade-foot toads (Pelobatidæ) are a strangely distributed family inhabiting the western United States, Mexico, eastern Europe, and the Indo-Malayan region. Their special characteristic is the fact that the inner tarsal tubercle is large and is transformed into a shovel, which is covered with a hard, sharp-edged, horny sheath. Having this excellent tool these small and noisy toads rapidly excavate deep holes in the soil, preferring sand, and lie hidden during the day, but come forth at night to hunt. They resort to water only for a week or so of egg-laying in the spring, and remain unknown to most persons in whose neighborhood they are really numerous. Our common American one (*Scaphiophus solitarius*) is about two inches long, and brown above with darker patches.

This brings us to the typical toads, Bufonidæ, represented in all parts of the world except certain islands. A hundred pages might be filled with inter-

esting accounts of the manners and customs of the hundred or so species, many very different from those familiar to us.

All breed in water, resorting to ponds and pools in the early spring. Where many broods have hatched the young can be met with in myriads, the ground literally swarming with them; and as they are naturally stirred up by a sudden warm rain, perhaps after a drought, people will occasionally affirm as an observed and well-ascertained fact that "it has rained toads"—something that never occurs except in the very rare cases when a cyclone has scooped the water and everything in it out of a pond and scattered it abroad.

Most of these young, migrating toads disappear as food for birds, snakes, etc., or die of disease. The food of young and old consists of insects, worms, snails, and the like; and it is an easy thing to tame toads and have much amusement in watching them at work in the early evening, for they are crepuscular in habits; and the wise gardener will see that they are not disturbed in their beneficial service of catching and devouring insect pests, unless they are so numerous as to be a nuisance.

The smallest North American toad is the oak toad of the Southern States, which is only an inch long. When, in the breeding season, these diminutive toads flock to the pools in great numbers, they keep up an ear-splitting chorus of shrill *peeps*, like so many young chickens.

#### FROGS AS NURSERY MAIDS AND WEATHER PROPHETS

The tree frogs are a very large family (*Hylidæ*) distributed all over the world, except Africa, but

most of the species belong to the steamy forests of tropical America. All are of small size, have smooth skins, normally greenish, but very changeable in color to adapt the creatures to the hue of their surroundings, as a protective device; and most of them inhabit trees. To enable them to do this the toes end in expanded, padlike disks, the contraction of which, when the foot is pressed against a surface, produces one or more furrows and, in addition, causes the exudation of a little mucilaginous liquid. The foot pressed against the surface expels the air, and this fact, aided by the stickiness of the pad, enables the frog to hold on to even a vertical plane of glass. All Hylidæ have a voice, often very loud, and enhanced by membranous sacs under or on each side of the throat, or in some cases internal; this sac, when blown out may be almost as large as the creature's body, as may be seen in our common gray tree frog when "singing." This species, like most others, becomes very noisy in the evening, in cloudy weather and before rain, with its not unmusical croaking; and a similar European species is kept in confinement by some people as an interesting pet and weather prophet.

The most interesting thing about the Hylidæ is their various methods of breeding, for while most of them lay their eggs, up to a thousand in number, in the water, many produce but a few, and attach them to the body.

A large tree frog called in Brazil "ferreiro" (smith), makes a sound like a mallet slowly and regularly struck on a metal plate. This frog actually builds a nursery in the shallow edge of a pond, where a basin-shaped hollow, with a rim, is formed by the broad-handed female. Here she leaves her

eggs, safe from egg-eating fishes or insects, as the rim forms a wall higher than the surface of the water. A Japanese frog makes a similar basin, then produces a liquid which she kicks into a froth, and into the midst of this the eggs are dropped, and there the hatched larvæ develop, and remain until the gradual collapse of the mud rim sets them free.

In these and similar cases the eggs and tadpoles are abandoned by the parents; but many frogs watch over and care for their young. Some carry the young in a pouch on the back, but how it is accomplished is not known. A West African species carries its eggs in its mouth; and the male of Darwin's frog, of Chile, carries the eggs in a great vocal pouch beneath its throat, which subsequently forms a nursery for the tadpoles until they emerge as young frogs.

It must be noted, however, that some of these examples belong to the related family Cystignathidæ—a very extensive family largely represented in Central and South America.

The remainder of the tailless amphibians are assembled in the numerous and widely distributed family Ranidæ, which is that of the "true" frogs. The typical subfamily, Raninæ, is cosmopolitan, except as to Australia and South America south of the Amazon basin; but some less typical forms are confined to the tropics, and include several strange species, such as the little arboreal *Dendrobates* frogs of Brazil, one of which is famous for furnishing in the secretion of its skin a dye that when properly applied turns the green plumage of tame parrots into yellow—a fashionable tint. These small and pretty frogs are noted for their solicitude for their young,

carrying baby tadpoles on their backs—where the infants creep and become attached—from place to place, as safety or better water conditions suggest.

The North American frogs are good examples of the ranine race, and those more commonly seen are the following:

Leopard frog (*Rana pipiens*), green with irregular black blotches, mostly in two rows on the back; legs barred above; belly pale. Eastern specimens are more olive than bright green.

Pickerel frog (*R. palustris*), light brown with two rows of large, oblong, square blotches of dark brown on the back, a brown spot above each eye, and a dark line from the nostril to the eye; upper jaw white and black. Habitat, eastern United States among mountains.

Wood frog (*R. sylvatica*), pale reddish brown; a black band across the pointed face. This smallest of our species is to be found only in damp woods, resorting to water only in early spring to deposit its eggs; and it is almost silent.

Green, or spring frog (*R. clamatans*), green or bronze-brown, brighter in front, with more or less small black spots; yellowish white below. This is a rather solitary frog, living in springs and small ponds, where it utters the familiar “chung” at frequent intervals. It is distinguished by the enormous size of its eardrum.

Bullfrog (*R. catesbiana*), greenish, brightest on the head, and with small dark spots on its back; legs blotched; eardrum large; toes broadly webbed. Length five to eight inches, breadth four to five inches. It utters a roar not unlike that of a distant bull, and a company of them on a still summer evening will awaken the neighborhood. Bullfrogs are

present throughout the eastern United States and Canada, west to the dry plains; and furnish the market with "saddles" (their hind legs) as a table delicacy when fried. These frogs may lay 12,000 eggs apiece.

All our frogs lay their eggs in water in rounded masses, not in strings, as do the toads, usually attached to some submerged stick or plant stem. The tadpoles, light in color, are very voracious, and feed on every sort of flesh that they can bite off and chew with their horny jaws. On the approach of winter the frogs—except the wood frog, which hibernates in the loam of the forest, or in some rotten stump—sink into the mud of the pond or marsh where they live, and pass the cold months in torpidity. Their food is almost exclusively insects, caught by the tongue, but the big bullfrogs seize with their mouths any small creature that comes their way.

## CHAPTER XX

### REPTILES—MONARCHS OF THE MESOZOIC WORLD

**W**HAT is a reptile? It is a cold-blooded, air-breathing vertebrate, with one occipital condyle, complete right and left aortic arches, red blood and a covering of scales. The classification of the class (Reptilia) recognizes the existence of many distinct subdivisions, as follows:

- Proreptilia* (extinct).
- Prosauria* (extinct, except the tuatara).
- Theromorpha* (extinct).
- Chelonia*—Turtles; tortoises.
- Dinosauria* (extinct; dinosaurs).
- Crocodylia*—Crocodiles; alligators.
- Plesiosauria* (extinct).
- Ichthyosauria* (extinct; fish lizards).
- Pterosauria* (extinct; pterodactyls).
- Pythonomorpha* (extinct; mososaurs, etc.).
- Sauria*—Lizards; snakes.

This surprising diversity of groups, each so widely isolated, as is implied by separation as subclasses—divisions of almost the highest rank—shows that the class developed in favorable circumstances that stimulated enterprise, so to speak, and resulted in rapid variation of habits, terrestrial, aquatic, arboreal, and aerial, and consequently of adaptive structure. The fact that most of the subclasses are extinct also shows us that the story of the Reptilia is mainly a tale of the departed glory recorded in the archives

of the rocks; and we shall hardly be able to understand living reptiles properly without knowing something of their prehistoric development into the dominance to which they rose in the Mesozoic era, which we call Age of Reptiles, and their subsequent decadence.

The first subclass covers certain most ancient skeletons and parts of skeletons that naturalists are not yet agreed are true reptiles, some considering them stegocephalian amphibians. Anyway, they indicate plainly that it was from that group of Amphibia that the variety sprang that developed into what, in time, became the distinct reptilian type. The first distinct product of this departure from the stegocephalian stock appears in the fossils of a division of the second subclass, the Prosauria (*pro*, "before"; *saurus*, a "lizard"), named Rhynchocephalia ("beakheads"), which, although lizard-like in general form, retain many amphibian characteristics of structure. Now the amazing and extremely interesting thing about this is that a representative of this earliest of true reptiles is still living—probably the premier peer among all vertebrates, reckoned by length of ancestry. This most primitive of reptiles, illustrating how hundreds of ancient species known to us only by a few bones must have appeared and acted in life, is the tuatara of New Zealand, catalogued in science as *Sphenodon punctatum*.

It has the shape and general appearance of a big lizard, dull in color and with a granulated rather than scaly hide, and an oddly shaped head, toothless in the adult, when the jaws become somewhat like a horny beak. Yet it is not a lizard any more than it is a crocodile or a turtle, but combines

features of all three in its anatomy. Hence it is what naturalists term a synthetic or generalized race (as is the case with all very primitive creatures) out of which more and more specialized groups and species may be, and are, developed, each sorting out and strengthening some particular characteristic of structure, continuously modified by adaptations to habits and environment until a separate type results. The ribs, for example, in the tuatara are remarkable for the presence of hook-like processes that project backward from each rib over the next rib behind it; such processes occur elsewhere only in the crocodiles and the birds. Behind the breastbone are rodlike bones embedded in the muscles of the belly; they occur again in the ancient fish lizards and modern crocodiles, and probably gave rise to the under shield of the turtles. And so on.

The tuatara is verging on extinction. It has nearly disappeared from the mainland of New Zealand, but is now protected on some small adjacent islands where it dwells in burrows which it digs and then shares with petrels. During the greater part of the day the tuataras sleep; and are fond of lying in the water, being able to remain submerged for hours without breathing. They feed only upon other animals.

The third subclass (Theromorpha, "beast-shaped") comprises very ancient reptiles whose remains lie in the rocks of Permian and Triassic age, principally in South Africa, and exhibit a skull, and especially teeth, so much resembling those of carnivorous mammals (for instance, those of a dog) that at first their true nature was mistaken. These creatures have excited the most profound interest, not only because they present so many differences from the

Prosauria, but also, and chiefly, because it is from their ranks that we are able to trace, with no small degree of certainty, the origin of the Mammalia.

#### THE SOURCES OF TORTOISE SHELL AND TERRAPIN STEW

The turtles and tortoises are of a very ancient group (*Chelonia*) and one very distinct among reptiles, by reason of their armor. What is known as tortoise shell is the series of horny plates, in some species of beautiful texture, in others thin and dull, or even leathery in character, that covers the underlying bones that form the real protection to the animal's body. In embryo (unhatched) turtles the skeleton is much like the ordinary four-footed type, with the vertebræ separate, a full series of ribs, and the limb bones in their proper places. As growth proceeds, however, changes occur rapidly, but least in the oceanic "leathery" turtle, in whose skin nodules of bone expand and join into a mosaic of plates covered with a thick, coriaceous hide. But this skin remains quite separate from the skeleton beneath, which fact places this animal in an order *Athecæ* ("lacking a case"), quite by itself. All other chelonians are classified in a second order *Thecophora* ("case-bearing"), and in them the changes that go on in the skin to produce the turtle's shell are far more complete.

If you peel off the horny shields on the upper shell, or "carapace," you will find beneath them a central, lengthwise row of squarish plates of bone, on each side of these a row of similar plates, and outside of these a marginal row of small plates—all knit together at the edges, the zigzag lines of juncture, or "sutures," being plainly visible.

When we dissect a turtle we find no layer of skin or flesh beneath these plates, but discover that they lie directly on the bones of the skeleton and are a part of it. This is what has happened: The vertebræ have grown together, and the backbone is a tube upon which the original nodules in the skin have become fixed, and have broadened into the central line of plates. Those nodules that lay above the ribs have become fused with them so that no trace of ribs is left, except where their heads have become fused with the backbone, and they have broadened into the side rows of plates; and the marginal skin has become transformed into the marginal plates. Similar alterations have produced the under shell, or "plastron," replacing the skin; and adaptive changes have altered the usual relations of the limb bones to the rest of the external skeleton. The carapace and plastron are usually connected by a "bridge" of bone.

Into the space within this shell most tortoises may withdraw the head and tail which, like the feet, are covered with horny scales. The head has good eyes, and a nose with a lively sense of smell, which the creature utilizes in selecting its food; but its hearing appears to be dull. The mouth has no teeth, but the lips are coated with horn, making a parrot-like beak that can inflict a severe bite. Horny spines often grow on the legs, or tail, or both, assisting in both defense and offense.

The chelonians are a very ancient race, and one that has changed remarkably little since its beginning. The great age accounts for the very wide distribution of turtles closely related, and also for the fact that they inhabit land, fresh and salt water; those of the land being, no doubt, the oldest. All

turtles lay eggs, the shell of which varies, according to kind, from a parchmentlike envelope to a hard, shining shell; but the process of generation is slow and curiously complicated.

The respiration of the *Chelonia* is interesting. The lungs are spongy masses, attached to the upper shell. As the rigid case does not permit of their expansion by breathing, the necessary vacuum is made partly by the neck and limbs, which act like pistons as they are drawn in and out, the air being swallowed or pumped into the lungs. Most chelonians may exist for a very long time without breathing, and can stay for hours or even days under water. No animal, perhaps, is harder to kill; and all turtles have long lives, the giant turtles of the Galapagos and their kin living more than 100 years.

The list of *Thecophora* begins with the suborder *Cryptodira*, whose members have the carapace covered with horny shields, and consists of the family *Chelydridæ*, composed of our two snapping turtles, the familiar northern one, and the southern alligator snapper. They inhabit stagnant pools, especially deep channels in swamps and slow rivers such as the bayous of the lower Mississippi Valley, and often show only the tip of the nose as they prowls about close beneath the surface in search of prey—anything they can seize. They take the hook readily if baited with fish or flesh, but stout tackle and a strong arm are needed to land one when full grown; and the act is dangerous to the catcher, for they are the ugliest brutes in the country, and to be bitten by one is a very serious experience. Nevertheless, the young are caught for market in large numbers, for they are excellent food. One curious fact about them is not generally known, namely, that when

lying still, like a piece of old log covered with mud and moss, they protrude a pair of wormlike filaments from the tip of the tongue, whose wavering attracts fishes to their doom. Louis Agassiz says of the great alligator snapper of the Southern States, which when walking on land carries its body high on the long legs, much like an alligator:

"They are as ferocious as the wildest beast of prey, but the slowness of their motions, their inability to repeat the attack immediately, their awkwardness in attempting to recover their balance when they have missed their object, their haggard look, and the hideous appearance of their gaping mouth, constitute at such times a picture as ludicrous as it is fearful and revolting. Their strength is truly wonderful. I have seen a large specimen bite off a piece of plank more than an inch thick. . . Fishes, salamanders and young ducks are their ordinary prey. They lay from twenty to forty or more round eggs, only about the size of a small walnut, in holes which they dig in sloping banks not far from the water."

These snapping turtles probably represent well the disposition and habits of the extinct predatory reptiles; and give us a hint of why the race succumbed to the more active and intelligent mammals that were growing up around them toward the close of the Mesozoic.

This brings us to the great family Testudinidæ, which is scattered over the whole world except Australia, and contains almost all the ordinary tortoises, mud turtles and terrapins, some of which are entirely aquatic, others amphibious, others wholly terrestrial. Among the most typical and widely distributed are those of the genus *Chrysemys*, to which "mud turtles" belong. The com-

monest species in the Eastern States is the painted turtle *Chrysemys picta*; in the West, *C. marginata*. These and other species of North and South America are very pretty when young, the ground color of the upper shields being green, variegated with yellowish or blackish markings, often in delicate patterns. They are carnivorous, depend mainly on



TERRAPIN

*(Malaclemys palustris)*

(After Babcock. Boston Society of Natural History)

fish, but eat many insects and their larvæ. In winter they hibernate in holes in a bank of their pond.

To the genus *Clemmys* is credited the "sculptured" wood tortoise, the keeled plates of whose back are marked with fine concentric grooves and radiating black lines; and the equally common speckled one, black with round, orange spots. Both spend long periods wandering in woods and fields in search of worms and insects. Closely related to them are the salt-marsh tortoises known as terrapins, which are so much of a luxury in the eyes of those fond of good dinners that probably the favorite one, the

"diamond back," would be extinct had not protective measures, and cultivation in captivity, saved the life of the species. Several other terrapins are to be found in the marshes of the Southern States, but not in other countries. Another relative is the interesting little "box tortoise," which is often kept as a pet, and will become very tame; its highly convex shell is colored black and yellow, or orange-brown,



BOX TORTOISE

(*Cistuda carolina*)

(After Babcock. Boston Society of Natural History)

but no two are alike. The eyes of the male are red, those of the female yellow. It is called naturally enough a "box" tortoise, for, by means of a flexible joint line across the plastron, the fore and hinder halves can be brought up to the ends of the carapace, shutting the whole body inside a tight box that will defy all enemies not strong enough—as are wolves, bears, and big cats—to tear it to pieces. This tortoise is exclusively American. It has become, as a species, wholly terrestrial, so much so that, although it is fond of drinking often, if it falls into the water it will drown. It thus leads us to the true land tortoises that fill the remaining genera of this family.

The typical and most numerous of these belong to the genus *Testudo*, with about forty species scat-

tered over all warm or temperate parts of the world except Australasia. Typically grazers and fruit eaters, they occasionally vary their diet with worms, snails, and insects. The eggs are hard-shelled, and the males are usually smaller than their mates. Most land tortoises hibernate in the ground during the cold half of the year, or they æstivate during the hot and dry seasons when in the tropics, but this is not an invariable rule. Several species of these land tortoises are common and well known in Europe and also in India, and are often kept as pets. They show considerable intelligence, and are decidedly fond of listening to music. Our best known American representative is the "gopher" (*Xerobates polyphemus*) of Florida, Georgia, and Texas. This turtle is nearly a foot long, with a high, rounded shell, dull brown in color, and the forefeet covered with hornlike scales and some spines—an armature for digging. The deserts along the Mexican border have several local species.

In this family belong the "gigantic" tortoises of the islands east of Africa and west of South America, now all but extinct, save a few in captivity in zoölogical gardens. In fact they differ from ordinary land tortoises mainly in size and in such minor points as distinguish the various species; some of them, indeed, are not excessive in bulk. The largest on record is a male of *T. daudini*, of South Aldabra, whose shell was sixty-seven inches long, and whose living weight was 500 pounds. A fossil species of the late Miocene in India had a shell six feet long, and then and later tortoises almost as big inhabited both Europe and North America, and more recently Madagascar. Their survivors are now restricted to two widely separated regions—the Galapagos

Islands, 600 miles off the coast of Ecuador, and the Mascarenes and other western islands in the Indian Ocean. The most interesting thing about this matter is the presence of these tortoises on these widely scattered islands, and the effects of their isolation. It must be noted that when discovered by European voyagers no one of these islands, except the Comoros, was inhabited by men, and none had any large or harmful beasts of prey.

On these peaceful islands plenty of food, an equable climate, and absence of enemies, enabled the tortoises in vast numbers to grow to a size impossible to their relatives on the mainlands. "Scattered over the many islands they were prevented from interbreeding, and thus it has come to pass that not only every group of islands, but, in the case of the Galapagos, almost every island has, or had, its own particular kind." How did these huge chelonians get to these islands? None like them is found on any continent at present, although they had a wide distribution in geological ages. We must conclude that those of the Madagascar region, at least, are the descendants of tortoises once populating "Lemuria," that land area which until mid-Tertiary time occupied the region of the western Indian Ocean, and of which the existing islands are the remains. A similar theory, for which there is geological evidence, may account for the survival of the Galapagos giant tortoises after those of the mainland had died off.

The next family is that of the big sea turtles (Chelonidæ), such as the green turtle, whose flesh is so highly prized a substance for delicate soups (but almost all turtle flesh is good eating), the hawksbill and the loggerhead. They abound in all

warm seas, and reach a large size, the green turtle often having a shell three to four feet long, but smooth, while that of the hawksbill is covered with horny plates with high keels and an overlapping arrangement, which are the tortoise shell of commerce. The green turtle is wholly vegetarian in diet, feeding on the large seaweeds, while the others are carnivorous, devouring fishes, mollusks, etc. All three resort in summer to sandy beaches, dig holes, and bury a great quantity of eggs.

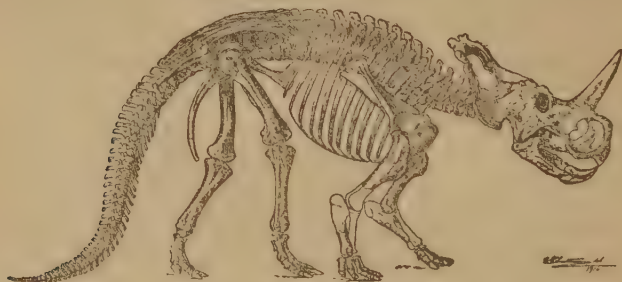
There remains a large group of fresh-water turtles, distinguished, in addition to other important structural peculiarities, by the fact that they withdraw the head under the shell by a sidewise bending of the long neck. They are entirely carnivorous, and occur in all tropical and some temperate countries, the ferocious "soft shells" of the Mississippi Valley and northeastward belonging here. A very curious one is the matamata of Guiana and northern Brazil, the biggest of its tribe, becoming more than three feet long. It gets its living by stratagem rather than by activity. The back of its shell is so roughened by coarse bosses that it looks like the bark on an old log, and ragged flaps of skin project from head and neck. These are kept in constant motion, and attract the attention of passing fishes and other creatures, whose curiosity often takes them too near the treacherous jaws of the concealed monster.

Our list of turtles ends with the one probably of most importance to mankind of all the kinds in the world. This is the "arrau" of the Amazon and Orinoco basins, where it is very abundant, and not only an essential element in the subsistence of the native Indians, but of great commercial importance on account of the eggs, which are periodically col-

lected in enormous quantities, chiefly for their oil. This oil is eaten, like the eggs themselves, or is used for burning in lamps, or as an addition to tar. The turtles are likewise eaten by man and beast. This turtle is large, sometimes three feet long; and it deposits a great number of soft-shelled eggs in the sand.

#### DINOSAURS—ANCESTORS OF BIRDS

No class of the extinct reptiles is so familiar, by name at least, as is that of the dinosaurs, mainly because of the enormous size of some of them, and the fact that their prodigious skeletons are exhibited complete in many museums. No other land animals ever approached some of them in bulk. A



HORNED DINOSAUR  
(*Monoclonius nasicornus*)

Skeleton restored from bones found in the Red Deer River region,  
Canada (American Museum of Natural History)

great number of species have been exhumed, yet as a group these reptiles are only imperfectly known, for the fossils are not scattered throughout the whole extent of Mesozoic deposits, but only in two limited periods of that era separated by two or three millions of years. All of them had short, compact bodies, long tails, and long legs for a reptile, and

instead of crawling they walked or ran, sometimes upon all fours, more generally on the hind limbs, like ostriches. They ranged in size from that of a cat to the prodigious bulk of the diplodocus or the brontosaurus, seventy feet long and perhaps twenty



MONOCLONIUS RESTORATION (DECKERT) IN TYPICAL  
LANDSCAPE

(American Museum of Natural History)

feet high at the hips, while an East African species appears to have been even far bigger. Some were herbivorous, and dwellers mainly in marshes and swamps; others ranged the uplands, armored for defense against huge predatory kinds, and still others had horny beaks like birds. It is believed, in fact, that our birds are descended from the same stock as these creatures, through an early offshoot.

## CROCODILES AND ALLIGATORS

These repulsive and ferocious reptiles (Crocodilia) are the bulkiest of the whole class, and most resemble the ancient aquatic dinosaurs, with which they are undoubtedly allied, although their precise derivation is undetermined. Their general shape is in conformity with the reptilian model, rather than indicative of any close relationship to lizards; indeed their closest living relatives are the tuatara and the chelonians. They have four legs of nearly equal size in modern examples, but in some of the older extinct forms of the Lias and Jurassic strata the hind legs were much longer than the fore pair, and broadly webbed, while other features indicate a purely marine life; but it appears plain that the crocodilians originated as land dwellers whose descendants, early in the history of the group, took to an amphibious method of life.

The eyes, nostrils, and external ears are situated on the upper surface of the head, so that breathing, seeing, and hearing are unimpaired in the water, the upper part of the head being usually raised above the surface when swimming. The nostrils and ears have valves which are shut when the animal is under water.

Crocodiles and alligators are mainly carnivorous, feeding on mammals and waterfowl, for which they lie in wait close to the edge of the water, sweeping them in by a blow of their tail, but the gavials feed almost exclusively on fish. All are oviparous, laying oval, hard-shelled eggs.

The order is represented by a single family, Crocodilidæ, including six genera scattered through the tropical and subtropical parts of the globe in the strange fashion that characterizes many of the

ancient groups of which present species are mere relics. Thus the American genus of alligators has also a species in China; and the Old World crocodiles are represented by a single, narrowly restricted species in the region of the Gulf of Mexico. Our common alligator (*A. mississippiensis*) inhabits the low coastal rivers and swamps from North Carolina to the Rio Grande, and remains abundant in the steaming bayous along the lower Mississippi, and in the swamps of Louisiana, but in Florida has been killed off, not only by the demand for its hide (as leather), but in a wanton way by tourists and sportsmen, until now its numbers are greatly reduced. It would have become nearly extinct were not its prolificness great, each female depositing thirty-five to forty eggs in the layers of the cone-shaped heap of a nest she makes on the bank.

Young alligators feed mainly on fish, but the old ones take more and more to getting birds and beasts for their dinner, stealing on them quietly as they swim, or when they approach the water to drink. The prey is dragged down and drowned. In the crocodilian throat the passage for air from the nostrils reaches much farther back above the mouth than in other animals, and the entrance of the wind-pipe may be closed by pressing together the base of the tongue and the soft palate, enabling the alligator to drown its prey without drowning itself. In two particulars our alligator is singular—its fear of man and its voice. When surprised basking on shore, as it likes to do, it will rush with awkward haste for the water; and there will get away or out of sight whenever a man appears. Hence it is safe to bathe in waters infested by alligators, which will retreat from the feared bather as far as possible. Never-

theless when an alligator is cornered it can and will make a very dangerous fight with jaws and tail that are truly formidable. But it rarely attacks unprovoked, except where a mother finds you tampering with her nest. As to its noise-making, the alligator is unique among reptiles in giving voice to a really loud noise, or bellow, which may sometimes be heard for a mile or more. It varies according to the size of the reptile from the gentle "mooing" of a small one to a "thundering and tremendous blast" by a big male.

In the half-submerged morasses of Florida, from Lake Worth southward, dwells a true crocodile, closely allied to that of the Nile, and first discovered there by William T. Hornaday in 1875. It differs from the alligator in the pattern of scales, in the relative length and vertical flatness of the tail, and especially in having a long, pointed snout instead of the broad, spade-shaped head of the alligator. Its general habits present no novelty, but it is more agile and, in captivity, more vicious than its cousin, while showing a similar dread of man in its wild home. This crocodile is found from northeastern Mexico south to the coast of Ecuador, especially in salt marshes.

Central and South America are the habitat of several species of caymans, which differ from alligators mainly in their teeth and the fact that protective scales cover the belly; they are blackish in color, and vary in size and markings, the largest, known on the Amazon as the black cayman, or "jacare usassu," growing to be twenty feet long; but the Indians pay little attention to it.

Crocodiles proper (genus *Crocodilus*) are distinguished by the fact that some of their foremost teeth fit into a notch of the upper lip, and are there-

fore exposed, as is not the case with alligators or gavials. One species lives in West Africa, another in India, another is wholly marine in habits (as were some of its extinct progenitors) and ranges from eastern India and southern China to northern Australia, a fourth is Australian, and a fifth Central American; but the best known of all is the so-called Nilotic crocodile of the upper Nile and the rivers of east central Africa. Formerly it occupied the whole course of the Nile, and was one of the sacred animals of the priestcraft of ancient Egypt. In Madagascar it is extraordinarily abundant, and has there the peculiar habit of digging long, ventilated burrows in the river bank, in which it lies, and where it stores its prey. Large old specimens may become fifteen feet in length, and their life is probably very long, for new teeth grow as fast as the old ones are lost, and when adult they have no known enemies except one another, but their eggs are sought for by several kinds of birds, lizards, and so forth, and the old ones devour many infants.

Crocodiles abound in all the sluggish rivers and estuaries of central Africa, and are more destructive of human life than even lions or leopards, and kill much game and many domestic animals. Lying in wait close to the bank, they make a rush, seize by the nose or leg any animal as it stoops to drink; or, stealing close to an antelope or goat standing at the edge of the river, they will, with a sweep of the tail, knock it into the water, and grasping it with their jaws bear it down to a horrible death. The crocodile does not at once tear its victim to pieces, as do the alligators, but pushes it into some hole in the bank to decompose before being consumed. Major J. Stevenson-Huntington says:

“At Sheshike, on the Zambezi, a paramount chief, who lived some forty years ago, used to derive great amusement from watching slaves and criminals being thrown to the crocodiles, his chair being brought to the river’s bank in the cool of the afternoon that he might enjoy the spectacle in comfort. The crocodiles at this place never forgot those halcyon days, and, until very recently, it was almost certain death for anyone to drink at the river, or attempt to draw water, except within one of the protecting screens of logs which were erected for the purpose. . . . On the other hand there are some large pans in Amatongaland, which, although full of the reptiles, are said to be quite safe to bathe in, attacks on human beings being unknown. . . . Always cunning and suspicious, the crocodile at times evinces considerable audacity in the pursuit of his prey. Natives are occasionally knocked off the gunwales of their canoes by a flick from the tail. I recollect Major Gibbons, standing upright in the stern of our little aluminum steam launch on the Zambezi, with the tiller between his feet, nearly losing his balance through an attack of this kind. I have heard of a native, sleeping on a hot night in the doorway of a hut close to the river, being attacked and dragged in.”

Despite this frequent attack on large prey, fishes are the main reliance of the African crocodiles for subsistence.

As opposed to this terrifying record from eastern Africa, the “long-snouted” crocodile of the west coast rivers offers a mild reputation, since it is content with fish, frogs and water birds as food, and fears men more than it is feared by them. The natives hunt it for the sake of its flesh. Crocodile

meat is considered good in all uncivilized parts of the world, but most white men dislike its musky flavor; the same may be said of the eggs of these reptiles.

The Orient possesses a variety of crocodiles, the best known of which are the marsh crocodile, a near relative of the African species, and the gavial, placed in the genus *Gavialis*, and distinguished by its long, slender snout and weak teeth. This gavial abounds in the Ganges and other rivers of northern India and Burma, where it is numerous, and frequently exceeds twenty feet in length. A second species is found in the Malayan archipelago. It feeds almost exclusively on fish, and so rarely harms man or beast that it is regarded as harmless. The marsh crocodile, or "mugger," is also of great size, and inhabits the rivers and marshes of India, Ceylon, and the Malayan islands. It is a fish eater and an arrant coward, feared by no one under ordinary conditions. It was, perhaps, originally, as a matter of gratitude for this harmlessness, that the custom arose among the Hindus of venerating this reptile. In some places, as notably near Karachi, large numbers of muggers are kept captive in ponds, and attended by priests and devotees who guard and feed them.

A third species is the formidable "estuarine" crocodile, which frequents the tidal portions of rivers from the Bay of Bengal to China and Australia. It exceeds all of its race in stature, usually exceeding twenty feet long, and one old specimen on record was thirty-three feet from tip to tip. It is held in great fear by fishermen, for in many cases it develops man-eater proclivities, and has all the ferocity and resourcefulness of its Nilotic cousin. The

salt-water habitat of this species recalls the fact that among the many kinds of fossil crocodilians known, from the Lias onward, one was a purely marine form.

The crocodiles are followed in the classification of the reptiles by several extinct groups, known only as fossils of the Mesozoic Age. The first of these is the subclass Plesiosauria, containing a series of predatory creatures characterized by very long necks, short tails, and feet that in the older forms indicate a terrestrial existence, but later exhibit a progressive change to paddles, showing that finally the plesiosaurs were wholly aquatic. This was accompanied by a steady increase in size, until finally a length of at least forty-five feet was reached—chiefly by extension of the neck—in the elasmosaurus of the Cretaceous rocks of Kansas.

Another subclass, Ichthyosauria, restricted to the Mesozoic Age, were large, swimming, marine “fish lizards” with a somewhat whalelike form, the front limbs transformed into paddles, and the snout in the form of a long bill filled with sharp teeth. They lived on fishes, cuttlefish, mollusks, etc., and had the general habits of sharks. They died out early in the Cretaceous epoch, and left no descendants.

A third extinct subclass is that of the pterodactyls, or “flying dragons” (Pterosauria), which possessed the air throughout the Mesozoic Age, and filled the place of birds in the fauna of that period, although they had no relationship to the real birds that came later. Some were no larger than sparrows, but later ones spread their leathery wings twenty feet or more. The origin and real affinities of these winged reptiles are unknown and they left no descendants.

We find in the Cretaceous formations skeletons of very long, slender marine reptiles (Pythonomorpha)

with a lizardlike head and all four limbs in the form of paddles, of which the mososaurs are the best known. These were the latest of the Mesozoic reptiles; and about the time of their disappearance we begin to find the earliest fossil suggestions of the subclass Sauria which contains our modern orders



MESOZOIC FLYING REPTILE (PTERODACTYL)

(Restoration, after Owen)

Lacertilia, the lizards, and Ophidia, the serpents. Neither of these owe their ancestry to any of the fossil groups just mentioned, in spite of superficial resemblances, but "their origin has probably to be looked for among the Prosauria, of which *Sphenodon* (the tuatara, see page 183) is the only surviving member." They are also very distinct from crocodiles in structure.

#### LIZARDS AND CHAMELEONS—TURNCOATS OF THE WOODS

Lizards (Lacertilia) are creatures of hot climates, and especially of deserts, and they exhibit an almost endless variety of shape, size, structure, and adaptations to their surroundings and a mode of life

that is primarily dictated by their food. The majority are terrestrial, but some species are semi-aquatic. There are climbing, swiftly running, and even flying forms, while others lead a subterranean life like earthworms. Most of them subsist on animal food, varying from tiny insects and worms to birds and mammals, while others live upon a vegetable diet.

Lizards, like snakes, have a scaly skin covered with a thin, horny pellicle which is shed from time to time, flaking off in pieces except in the wormlike species, where it is sloughed whole as by snakes. In most lizards the scales are well developed, and "shingle" the back and sides of the body, but in some they are like little tubercles, giving a granular appearance—a good example of which is the "Gila monster" of Arizona. Lizards are, as a rule, adaptively colored according to their habitat, so that browns and grays prevail in the sand-running species or those, like the monitors and iguanas, that are mostly aquatic; but brilliant hues in varied, even fantastic, patterns adorn many of the small, agile, tropical kinds, whose safety lies in their swiftness of movement and cleverness in hiding. This is supplemented in most species by the capability of changing color, a faculty that is most serviceable in the chameleons, by rendering them more or less invisible to the hawks and other animals that try to catch and eat them. Some of the more sluggish, earth-dwelling kinds are further protected by many spines sprouting from the skin, as is familiar in our western "horned toad," and in the fearsome-looking "moloch" of Australia; and the iguanas are provided with an erectile spiny crest along the ridge of their backs, most notable in the basilisks.

A strange characteristic of most lizards with slender tails is the power to part with them at a moment's notice. If an enemy seizes this appendage, which often is held temptingly aloft, it breaks off and its owner escapes before the would-be captor has had time to recover from his surprise. Within a short time a new tail is developed, but it is never so perfect as the original organ.

Most lizards lay eggs, few in number, and with shells hard in some families, parchmentlike in others, that are hidden in a hole in a dead stump or some similar place of concealment, and are left to be hatched by the warmth of the sun. Many lizards retain their eggs until nearly ready to hatch, and so are practically viviparous. The embryos have an "egg tooth," as do turtles and snakes.

The Lacertilia are naturally divisible into three sections, namely, geckos, typical lizards, and chameleons.

The geckos are a large and ancient family represented in all tropical countries, and some species are common along both shores of the Mediterranean, but none reach the United States. They are small, plump, flat-headed, and mostly somber in color, but this is changeable; the skin has a granular surface, but regular scales cover the desert-dwelling species. One peculiarity of the group is the adaptation of the foot to the habit of climbing about rocks and trees. The undersurface of the toes has a series of plates, which serve as adhesive pads wherewith the animal is enabled to climb not only trees and the smooth rocks, but a windowpane or to run along the ceiling with the ease of a fly. Another peculiarity is the fact that the eyeball is covered by a "watch glass" of transparent skin, under which the little animal

rolls its eyes and stares at you with vigilant interest. Geckos are nocturnal in habit, and as evening approaches come out from their retreats and become active in hunting for insects, and in avoiding the other lizards, snakes, and so forth, that would like to seize and eat them; and it is then that are heard their low, two-syllabled, clucking calls that give them the name "gec-ko." These funny little lizards are utterly harmless, come into houses, and are easily tamed, yet are regarded in many countries with superstitious dread and that foolish fear of poison that is attached to most small lizards and newts. In the Orient several strangely modified forms exist.

The lizards proper (*Lacertæ*) number several hundred species classified in eighteen families, and differ vastly in size, shape, food, and place and manner of life. Some, like the degraded slowworms, are limbless, scaleless and in their serpentine form and underground life resemble worms more than anything else. Others, such as the "flying dragons" of Malayan forests, have developed great winglike expansions of the skin on the sides, folded close to the body as they climb about the trees, but capable of being spread as supports when they wish to take a long gliding leap to some distant perch; and an Australian species has similar skin expansions that can be raised into a broad ruff around the neck that gives the little animal a terrifying aspect. The many kinds that live in deserts have the dull hue of the ground, or may bristle with spines, of which the squat "horned toad" of California is an excellent example; while those that scamper about the trees and rocks of the equatorial region are often brilliantly striped or spotted in reds, greens and blues. Many are pugnacious and able to bite severely, but

the only one whose bite is poisonous is the *heloderma* of the Mexican border. This is a fat, sluggish, black and yellow creature, about a foot in length, that inhabits the hot desert sands. Fortunately it is slow to anger, but when it does bite there flows into the wound a poison which has the same effect as the venom of the rattlesnake, although less copious and virulent. Severe illness, and in a few cases death, have resulted from the bite of this ugly creature, which is more commonly known as the "Gila monster," because it is prevalent in the valley of the Gila River in southern Arizona.

As the great family *Agamidæ* is confined to the Old World, so the *Iguanidæ* belongs to America, where several species are numerous in the tropics, and reach a size of three to five feet, much of which is tail. They live in trees, feed on vegetation, and haunt the banks of rivers into which they jump on the slightest alarm. One traveler relates that along the Mosquito Coast of Nicaragua, when a person is going in a canoe up some of the narrow, unfrequented creeks, he encounters quite a shower of iguanas, and runs some risk of getting his neck broken, for a big iguana will weigh twenty-five pounds or more. Their flesh, resembling that of chicken, is a favorite article of food and iguanas are constantly brought to rural markets. The family contains about 300 species. Among them is the common little "chameleon" (*Anolis*) of our Gulf States, so often sold to tourists as a curiosity, and brought north to die of cold and neglect. It is golden green on the upper surface, and white on the under, and the throat, when inflated, glows with vermilion; it is a harmless, active little tree dweller, and will change its colors to suit its surroundings with

astonishing rapidity. In another genus (*Sceloporus*) is placed the blue-tailed, variable, "fence lizard," or "swift," which is known throughout the eastern United States; but the common small lizards of the Pacific slope belong to *Gerrhonotus* and other genera.

The largest lizards of all belong to the two families *Varanidæ*, the "monitors" of Africa and eastward to Australia, and *Teidæ*, the "tejus" of Central and South America. They are singularly alike in appearance and habits—long-tailed, slender, smooth-skinned, carnivorous creatures, living in all sorts of places, varying with the numerous species, and both hated and utilized by the natives of the various countries they inhabit. Some monitors are more than seven feet long. The American tejus, such as the big "teguexin" of Brazil, frequent forests and plantations, where their strength and speed enable them to catch all kinds of animals, from insects to worms, frogs, snakes, mice, and birds. "They take chickens and eggs from the farms, and they are frequently hunted down by dogs for the sake of their flesh, which is considered good to eat. They defend themselves with lashing strokes of their long tail and with their powerful jaws."

The chameleons differ so much from other lizards that they have been placed by some systemists in a different suborder. The chief differences are three. First, the feet, terminating rather long legs, have the fingers and toes so arranged that two digits oppose three as do our thumbs the palm of the hand, and the animal can grasp a branch just as we would, giving so firm a grip that chameleons are exceedingly agile climbers, and may take as many odd attitudes among the branches as would a monkey. Second, the eyes are very large, but the eyelids have

grown together over them, leaving only a small hole out of which to look. The right and left eye roll about incessantly, and independently, giving a most comical squinting effect—but no lizard sees with both eyes at once! Third, the tongue has reached an extraordinary development. When the mouth is shut it is withdrawn into a tubular sheath at the back of the mouth; but when a fly is seen and wanted it is shot out like a released spring, seizes the fly in the flaps at its club-shaped extremity, and is quickly withdrawn. This tongue may be thrust out to a distance equal to the length of the body, less the long, tapering, prehensile tail, which is another important part of the equipment of these active tree dwellers. The skin is not scaly, but granular in appearance; and the skull is prolonged behind into a pointed helmetlike form that is distinctive of the group.

Chameleons are most celebrated, however, for their remarkable power of changing their color, but this is by no means always, or perhaps often in direct response to the hue of their immediate surroundings. Dr. Hans Gadow has made an extensive study of his captive specimens of the common chameleon of the Mediterranean region, and confesses himself baffled in the attempt to learn an explanation of the influences, external or mental, that causes the alterations of hue. One judges from his observations that they are mainly the expression of fleeting emotions—but who can read the emotions of a lizard?

But if we do not know the *why*, the *how* of these fluctuations of color is well understood, and is briefly stated by Prof. Pycraft:

“The horny outermost layer of the skin is colorless; in the layer beneath this are embedded irides-

cent cells with striated surfaces. Below this, in the deepest layer of the skin, *cutis*, are a large number of cells filled with refractive granules, chiefly guanin crystals. These cause white color by diffuse reflection of direct light. Nearer the surface are cells filled with oil drops, and these give a yellow color. In the granular mass are embedded numerous color-bearing granular sacs or chromatophores, containing for the most part blackish brown or reddish pigment. The branches of these sacs being contractile, the contained granules of color are drawn away from or toward the surface of the skin, and thus, combining with the stationary color, effect a corresponding change in the coloration of the animal."

The chameleons are an African family, but a few of the fifty or so species belong also to the western coast of India and Ceylon, and one is a resident of southern Spain. They vary in size from that of a mouse to a species in Madagascar two feet long.

The lizards and snakes are the most recent developments of the reptilian line of vertebrate evolution. No undoubted lizard remains have been discovered antedating the end of the Cretaceous epoch; and no fossil evidences of snakes are much older than the mid-Tertiary, yet these are surprisingly similar to existing forms. The affinities of both groups seem to be with Pythonomorpha.

## CHAPTER XXI

### SERPENTS, GOOD AND BAD

**S**NAKES (Ophidia) are the newest and most flourishing branch on the reptilian family tree, whose trunk and lower limbs are dead or dying. They differ from lizards mainly in their elongated and limbless form (which, however, had been foreshadowed by certain lizards) and more particularly in the formation of the mouth. Instead of a solid union of the bones of the skull, many of the bones, especially about the mouth, are connected by an elastic ligament, allowing the snakes to open their mouths widely enough to swallow larger prey than otherwise would be possible. The palatal bones, as well as the jaws, bear small, solid, recurved and pointed teeth, replaced by others from the same root pulp when lost; they have little chewing power, but are useful to seize and hold food which is then slowly swallowed by the snake gradually working its jaws ahead and over the object, until the muscles of the throat can grip it and slowly work it downward into the tubelike stomach. Serpents strive to turn their prey and swallow it headfirst.

The tongue in all serpents is a slender, extensible organ, forked at the tip, usually black, and always seen protruded and waving about when a snake is disturbed. Uninformed people call it a "stinger," but it is merely the animal's tongue and used as such. It serves the additional purpose of an instrument of

investigation, the serpent informing itself by touching with its tongue as to the nature of many things with which it comes in contact. It has, however, no stinging or other harmful purpose or power whatever. A rattlesnake's tongue would harm you no more than one of the little love licks that you get from your favorite puppy.

The eyes, which may be rudimentary in the burrowing species, or large in those of nocturnal habits, have no eyelids, and are covered with a transparent film of skin that is sloughed off whenever the skin is shed, which happens frequently in young, growing individuals, but only annually in adults, as a rule; and for a day or two snakes are blinded by the loosening of this covering. No snake has ear openings, and their hearing is dull. The sense of smell, however, is well developed, and it is probable that these animals obtain much food by its aid, even following a trail by the nose.

Serpents travel on their bellies, moving their bodies in lateral undulations, and often running with amazing swiftness. Every pair of ribs is connected at their lower ends with one of the large abdominal scales, or "scutes," and it is generally believed that the creature moves by the pressure and pushing of these scutes and rib points on the ground; but Boulenger, a leading authority, thinks that their importance has been somewhat exaggerated, although of undoubted use for the purpose of climbing, at which some species are remarkably adept.

Some snakes lay eggs with a tough, parchmentlike shell; others retain them within the body until the young are fully developed.

Snakes do not migrate nor wander far from their birthplace in search of food. Desert dwellers

burrow under the sand for protection from the heat, and go abroad at night, as is the habit of many snakes. In the colder climates the serpents hibernate, collecting in companies tangled together like a ball in some animal's burrow, or in a den among the rocks, the hardier ones occasionally appearing on warm days in winter. When they come out in spring they are likely to make their way to wet lowlands, in search of frogs, toads and mice.

The order is divided into nine families, which will now be considered in the order arranged by G. A. Boulenger of the Zoölogical Society of London. The first four families are small, wormlike, burrowing creatures, with a large number of species distributed in warm countries throughout the world, and regarded as relics of an ancient type. The beautiful coral snake of South America, which grows to a yard in length and is only partly subterranean in habit, leads from these to the great family of boas and pythons (*Boidæ*) which contains the biggest serpents that exist, or so far as we know, ever have existed. The members of this family have vestiges of pelvis and hind limbs, appearing externally as clawlike spurs. The *Boidæ* comprise sixty or seventy species and the range of the family is world-wide. They mostly prefer wooded districts, climbing trees, assisted by the short and partly prehensile tail. Some are semiaquatic. All are rapacious, and feed by preference on warm-blooded creatures.

The family is divided into two subfamilies, *Pythoninæ* and *Boinæ*, but the difference between them is confined mainly to certain bones in the skull. The pythons belong entirely to the tropics of the

Old World, except a single species in southern Mexico; and number about twenty species. The Boinæ are chiefly American. None is venomous.

A famous python is the six-foot, tree-dwelling carpet snake of Australia, black, beautifully marked with a pattern of yellow dots. A very large species is the reticulated python of Indo-China and the Malayan region, having an arrangement of dark lozenges on a lighter ground. India has a similar species, reaching a length of thirty feet, marked with reddish brown patches on a yellowish ground. This (*Python molurus*) is the one most often seen in zoölogical collections on account of its hardiness; but it is a savage creature, almost untamable. Like others of these big serpents it is able to make very long fasts; indeed their life, in this respect, seems to consist of gorges, followed by long periods—sometimes several months—of fasting and repose, entirely voluntary. It appears from observation of captive specimens that they have individual preferences for a certain kind of food, and perhaps wait for it; thus one in the Jardin des Plantes, Paris, refused various toothsome animals for months until a goose was offered, which it seized hungrily, and then sulked through long weeks until another goose was given.

Africa has two pythons, one (*P. regius*) confined to West Africa, the other (*P. sebæ*), common from the Sudan to the Cape. "The latter," William C. Scully says, "is the largest of African snakes, occasionally attaining a length of more than twenty feet, with a circumference of eighteen inches. One is recorded of twenty-five feet. It principally frequents rocky chasms in moist, warm forests. It is not dangerous to man, being quite nonvenomous, but it will fight fiercely if attacked, and the long, sharp,

teeth may inflict a severe bite. The python usually preys upon small animals, such as minor antelopes, monkeys, conies, and birds. Sometimes this snake coils itself at the bottom of a stream and lies with its nose just emerging. When a small buck comes to drink, the snake seizes it by the nose, the recurved teeth taking an inextricable grip. After the buck has been drowned the python coils itself around the body and crushes it for convenience in the process of swallowing. . . . The python does not regard the horns, which sometimes may be seen sticking out through the abdomen. These wounds quickly heal, the snake apparently being none the worse for the perforations.

“So far as I know the python is the only snake which incubates its eggs. Such, numbering from thirty to fifty at a brood, and weighing about five and a half ounces each, are usually laid in a deep rock crevice or in the deserted burrow of an ant bear or hyena. The mother coils herself over and around them.”

Let us turn now to the boas. Popularly the whole tribe is frequently spoken of as “boa constrictors,” but that is the scientific name of only one among several species, the *Boa constrictor* of the West Indies and tropical South America. It is the one most common and best known, and, as it is easily tamed, is the one often seen in the hands of performers with serpents in circuses, and exhibited in menageries. In many places in South America the natives, according to Leo Miller, keep them running at large about their huts to catch rats. In forested regions they spend most of their time in trees, but in an open country lie about on the ground, retreating when alarmed into some hole, as of a viscacha—their favorite prey on the plains.

Far greater and much more dreaded by the natives is the great water boa, or anaconda (*B. murinus*), of the Amazonian region, which is the longest of American snakes, and the worst foe of such river-loving creatures as capybaras and iguanas. The color scheme of the anaconda is greenish yellow above, with a single, or two alternating series, of large, blackish transverse spots, and one or two lateral series of blackish eyespots with white centers. The lower parts are whitish, spotted with black. The anaconda is very aquatic, and is usually found submerged close to the banks of the river, on the lookout for its prey. Although mammals and crocodiles are occasionally eaten by this snake, it prefers birds, these being constricted and eaten under water. Only a single instance of an anaconda having attacked a man is on record. Although it grows to a length of over thirty feet, it is sexually mature when about half that length.

Various very slender and agile species, the tree boas, belong to the tropical American forests, one of which is called the "rainbow" boa because of its marvelous iridescence in the sunlight. Another large species inhabits Central America and Mexico; and two small, brown secretive snakes, the "rubber" boas, more commonly known as "double-enders," because their blunt tails closely resemble their heads, are found in California and northward to British Columbia. The remainder of the family are scattered from Africa to the South Sea Islands.

#### ORDINARY SNAKES (COLUBRIDÆ)

We now come to the family Colubridæ, which embraces nine-tenths of all the modern serpents of the world. The more hardy species are to be found

north to about the summer isotherm of 41 degrees; and snakes are absent only from some of the South Pacific Islands, New Zealand and Ireland; Ireland never had any, despite the St. Patrick legend.

The best arrangement of the Colubridæ is that by Boulenger, who, adopting Duméril's terms, has divided them into three series according to the character of the teeth.

1. *Aglypha*—All the teeth solid and not grooved. Harmless, that is, not venomous.

2. *Opisthoglypha*—One or more of the posterior maxillary teeth grooved. Mostly poisonous; a few tropical species.

3. *Proteroglypha*—Anterior maxillary teeth grooved or tubular. Deadly poisonous; cobras, coral snakes, etc.

The immense family Colubridæ is divided into several subfamilies, the first and most extensive of which is the Colubrinæ, in which are associated all the "harmless" snakes in the world except the boas and pythons. None exceeds twelve feet long, and most of them are much smaller. Nearly all lay eggs, but some bring forth large broods of living young, among which are our water snakes, and the striped "garter" and "ribbon" snakes so numerous in our meadows and gardens. These striped snakes (*Eutainia*) exist in a great number of "species" or varieties most confusingly varied in coloring, some having no stripes whatever. They are very hardy, living far toward the north in Canada, and are the last to go into hibernation and the first to reappear in spring. For this winter sleep they burrow deeply into soft soil, or where rocky places exist, seek deep crevices.

The water snakes of the genus *Tropidonotus* follow, with many representatives in all temperate countries, one of which is the "common grass

snake" of England—the only serpent in Great Britain except the viper and a rare little burrower. Ten species, with several varieties, are credited to the United States, some of which are ringed with irregular or broken bands of blackish on gray, others obscurely blotched, and some black or brown with red bellies. They are the ugliest of all our snakes both in appearance and in vicious temper; and are of no service to mankind, for their food consists entirely of fishes, frogs, toads, etc., obtained in or near the water. They live altogether in rivers, ponds and swamps; and by their dark bodies, flat heads, and keeled scales so resemble moccasins whose fierce, repellent attitudes they imitate, that in the South they are almost as much feared; hence it is well to note the differences. The harmless water snake is more slender than the deadly moccasin and may be told by the red spots on the abdomen; the undersurface of the poisonous snake is straw color, with black or gray spots on younger individuals, but has no red spots. The water snake has the plates on the underside of the tail in two rows, the moccasin in a single row. These snakes are agile swimmers and are able to spend a long time in hiding under water. They produce their young alive in broods of twenty-five to fifty, and they are as pugnacious as their elders.

Various small, ground-keeping snakes lead to another conspicuous American group, the racers and black snakes of the genera *Spilotes* and *Zamenis*, of which species and near relatives are numerous in Europe and Asia, a Malayan example growing to a length of ten or more feet—probably the longest of colubrines. Three different "black snakes" are known among us. The largest is the

"gopher snake" or "indigo snake" of the sandy parts of the southeastern States, which may approach eight feet in length, and it is a variety of the still larger yellow "rat snake" or "cribo" of the tropics, which is protected about villages and houses as a good-natured exterminator of vermin. Our variety has a useful breadth of taste and lack of choler, and its haste to escape into a gopher turtle's hole when a man appears gives it one of its names, while its glossy, blue-black color, relieved only by a reddish chin and throat, accounts for the other. They are real pets, showing no fear and offering no harm; the closely related "rat snakes" of India, on the other hand, although similarly protected as rattlers, are described as diabolical in temper, and thus usually remain untamable. To some extent in the South, but principally in the Northern States east of the plains, the commonest black snake is the "black racer," which west of the Mississippi, instead of being pure satiny black, with white chin and throat, appears in a bluish green hue, often with yellowish belly, and is known as "blue racer." Third, we have the less numerous and larger "pilot," whose scales are noticeably keeled and have each a touch of white. Raymond L. Ditmars takes great pains to relieve these snakes of various calumnies, as that they hunt for rattlesnakes and copperheads (whence the name "pilot"), as that they "constrict" their prey, as that they "fascinate" anything, and as that they maliciously attack human beings—on the contrary, they make frantic efforts to get away the instant their fears are aroused, and few things on earth can make better speed than this black rocket. If cornered, however, it will turn on the enemy, rear a third or

more of its length, and strike repeatedly with a force and rapidity hard to avoid. Yet both the common and the indigo species quickly become docile and show signs of recognition and partiality toward their human friends. The long, slender "coachwhip snake" of the South and the equally thin and swift striped "racer" of the Pacific coast are allied species.

The genus *Coluber*, to which belongs the famous *Æsculap* snake of central Europe, is represented among us by a series of large and gayly colored species. One is the yellowish, brown-blotched fox snake of the prairie States, which is a ground keeper and a great hunter. In search of rats and mice it often haunts haystacks and barns where it should be welcome. "One snake is worth a dozen traps, for the reptile prowls into the burrows and nests of rats and mice and eats the entire brood." Similar in size (six feet) and habits is the brilliant red-and-crimson corn snake of the Southern States, which is a great mouser and also an agile climber after nests of birds, whose eggs and young it likes. Another, even larger, coluber of the South is the four-striped chicken snake, useful in its pursuit of small rodents, but, like the pilot black snake, with too great a fondness for hen's eggs and young poultry to be liked by farmers.

The big, gray, blustering "bull snakes" of the southern and western parts of the Union take their name from their habit of emitting a loud and prolonged hiss when annoyed. They keep on, and under, the ground in sandy regions, feed on small mammals and birds, and are powerful constrictors; they are also noted for morose and savage dispositions. Next to these repulsive reptiles come in classification the beautiful and gentle green snakes—

slender little creatures that hunt for caterpillars and various insects through the foliage of bushes, among which their gracefully festooned length is hardly visible. South America has another group of very long and slender insect eaters and nest robbers known as "tree snakes," whose habits are similar but on a larger scale, and which have a wonderful power of riding securely on the branches, no matter how violently they are waved by the wind.

Passing over a number of small, smooth-scaled serpents, of which the pretty ringneck is an example, we come to the important genus *Ophiobolus*, which contains the king snakes, milk or house snakes, coral snakes and others, represented in the Old World by the genus *Coronella*. They vary in size from fourteen inches to six feet, and in color from gray with dark blotches to a ringed pattern of red, black, and yellow, often of brilliant beauty; but there is much individual variation.

The king snake might easily furnish material for a long chapter. Its name follows from its known disposition to pick a quarrel and fight with any serpent it meets, big or little; and quite independent of whether it is hungry, for it is as fond of eating its own kind as it is of lizards, toads, mice, birds and anything else that comes in its way on the ground, for it is not much of a climber. Our books are full of incidents of its destruction of poisonous species, and the popular belief is that it hunts for, and relentlessly pursues rattlesnakes, copperheads, etc., but the authorities assure us this is not so. If it accidentally encounters a rattler or moccasin, it kills, and perhaps eats it; but it does the same with any other serpent. It is an exceedingly quick and powerful constrictor, and careless of bites, for it is

entirely immune to venom. Captive specimens have been repeatedly hypodermically injected with the poison of all sorts of American venomous serpents, as well as bitten by them, and have shown little if any effect. But wounds enrage it. Winding its lithe body round and round the doomed creature, until every part of the shining length is engaged, it tightens with such strength that the victim is benumbed, unable to bite and quickly strangled. Nevertheless these snakes submit easily to confinement and speedily grow perfectly gentle and friendly.

The common northern representative of the genus is the house snake or milk snake—names given to several other species; it is also known as “checkered adder,” because of the general resemblance of its blotched form to the dreaded copperhead. It is gray above, with a series of large, chestnut-brown saddles on the back, smaller blotches alternating with them along the sides; the belly is white, marked boldly with square black blotches. The pattern and tints vary widely. This snake is a lover of warmth and a hunter of mice and rats, wild and domestic; and in search of them it frequents pastures and damp meadows, where such wild game abounds, comes much about stables and houses, and often creeps into the rural dairies that are usually close to springs. Serpents with these inquisitive habits are familiar in all parts of the world, and from time immemorial have been accused, among other iniquities, of milking cows and goats, and of drinking and spoiling milk and cream on the shelves in dairies and cellars. These beliefs survive among country people to this day, as I found out a few years ago by an extensive correspondence of inquiry, in which

incredibly absurd statements were made. Of course, well-informed persons know better. The keepers of reptiles at the New York Zoölogical Park, for example, find that snakes show no liking for milk. Captive specimens cannot be induced to drink it unless suffering from great thirst. It would be a feat beyond physical possibility for a serpent the size of the largest milk snake to consume enough milk from a cow—if the reptile should be so inclined—to produce an effect noticeable to the most minute degree.

We will mention only one other sort of our harmless colubrines—the “hognose,” “puffing adder,” “spreading adder,” as it is variously known; but the name hognose is the best. Its genus is *Heterodon*. Two species are common all over the eastern half of the United States and Canada, one an ugly mottled gray, the other black. They are about two feet in length, thick-bodied, with roughly keeled scales, a flat head and a pointed, upturned snout—altogether very unhandsome and forbidding-looking reptiles; and they profit by this in an attempt to frighten away whatever alarms them, while in reality themselves almost (sometimes quite) paralyzed by fear.

#### CORAL SNAKES, COBRAS, AND SEA SNAKES

The flattening of the head and neck practiced by the hognose as a gesture of readiness to fight, whether true or false in its implication of ability, is found among several non-poisonous colubrids elsewhere and indicates their approach in kinship to the “hooded” cobras that are the foremost representatives of the venom-bearing members of the Colubridæ. It will be recalled that we have been

sketching the "harmless" section (Aglypha), and have now to take up the two remaining "dangerous" sections of the Colubridæ, the Opisthoglypha and the Proteroglypha.

The principal tooth-bearing bone in a serpent's mouth is the forward half of the upper jaw, termed the maxillary. The maxillary of each side is connected with its fellow by a small, single bone in front (the premaxillary) and otherwise is connected with the loosely connected bones of the skull by those elastic cartilages that enable the mouth to expand and take in prey of a size more than equal to the snake's head when the mouth is shut. In the serpents that do not possess a poisoning apparatus the teeth on the maxillaries are alike in size, and solid; but in the venomous kinds some of the teeth are enlarged and grooved or channeled to conduct a flow of poison into the wound made by biting. This is the case with the poison-bearing sections of the Colubridæ mentioned above, and their difference is in the relative position of the poison-conducting teeth or "fangs" on the maxillaries.

In the Opisthoglyphs these teeth are situated near the posterior end of the maxillary, and are grooved on the rear side, where they receive the poisonous fluid from a sac in the cheek. The greater number of species of this group are residents of the Old World, although we have several representatives along our Mexican border, and more southward, especially in the tropics. Most of them are little dangerous to mankind, as it is difficult for them to inflict a wound by "striking." They first seize their prey and then use their rather short fangs. The poison has a paralyzing effect,

reducing the victim to helplessness. Some of these snakes must be regarded as decidedly dangerous, but fortunately all the American species may be quickly recognized by the peculiar marking on their heads, which has given the name "jew's-harp snake" to a common species of Arizona. It is believed that the vipers are an offshoot of an opisthoglyph ancestry, in spite of the forward position of their fangs.

In the Proteroglypha, on the contrary, the poisoning teeth, in all cases small, are situated near the front of the maxillaries, and they are much more dangerous reptiles, for they include the coral snakes and cobras (*Elapinae*) and the sea snakes (*Homalopsinae*), which are able to strike their teeth into anything they successfully attack.

The coral snakes (genus *Elaps*) derive their name from the broad bands of coral-red that encircle their bodies in most species, with narrow rings of black and yellow between. These brilliant colors, combined with the luster of the smooth scales, make them among the most beautiful of serpents, and a common species of our Southern States is called the harlequin. The genus is exclusively American, and nearly all belong to the tropics, where the largest become five feet long, and their bite is deadly to man. They keep to the ground, and much of the time under it, and are cannibalistic in their diet. The body is slender and cylindrical, the head small, and the eyes like beads. They are indocile, quick-tempered, and very dangerous to handle, despite the fact that they do not always resist being disturbed. Hence the widely prevalent opinion that they are harmless is a perilous delusion fostered by the fact that certain

innocuous southern serpents closely mimic the coral snakes in size and colors. It should be learned and remembered, especially by visitors to winter resorts in Florida, that the poisonous ones (Elaps) have the black rings bordered on each side by the yellow ones, while in the harmless species the yellow rings are bordered by the black; also, in the coral snakes the bands of color completely encircle the body, but do not in the other kind. A very elaborate illustrated account of the coral snake and its poison apparatus, methods and serious effects, was given by Stejneger in the "Annual Report of the United States National Museum," for 1893, Part II.

The remainder of the elapine serpents (about 125 species) belong to Africa and the Orient. Typical of them are the cobras of the genus *Naja*, of which the species (*Naja tripudians*) met with from Turkestan to southern China and the Malay islands, and named by Portuguese explorers "cobra de capello" (hooded snake), is world-famous. Several species inhabit Africa and differ little from the Indian cobras, but are equally deadly. The fangs in all this group are small and are fixed in the extreme front of the upper jaw, not being erectile like the long fangs of the rattlesnakes and vipers. Cobras vary much in coloration, and Mr. Scully reports that he has killed South African specimens of light yellow, jet black and all intermediate hues.

The cobra is a fierce fighter and, when reared up, with expanded hood, looks very formidable. Anterior to the head the ribs lengthen and then gradually shorten to normal dimensions. These lengthened ribs, about twenty in number, lie, when the snake is quiescent, more or less laterally along the spine. But when the snake becomes excited, the

neck bends and the ribs spring out at right angles. Over them the loose folds of skin expand umbrella fashion. When much enraged, the cobra spits drops of venom at its enemy. These are propelled a distance of about four feet.

The cobra is found all over South Africa, but is especially plentiful in the dry, sandy deserts northwest of the Cape. There extensive colonies of large mice abound, patches of ground being thickly honeycombed with burrows. In these the cobras dwell—apparently, as in the case of the puff adders, on the best of terms with their hosts, upon whom they principally feed, reminding one of the tenancy by the Western rattlesnake of prairie-dog “towns.”

A close relative of the cobra is the ringhals (i. e., ringneck), known as the “spitting snake,” the explanation of which Mr. Scully furnishes from personal experience thus:

“The ringhals, when excited, exudes a quantity of venom, which drips down the fangs and lodges behind the abrupt, horny, lower lip. Upon this the angry snake directs a blast of air through its extensible windpipe, with the effect that a jet of fine venom spray is emitted toward an enemy. This jet may reach a height of six feet. That the eyes are aimed at I have proved by experiment. If the poison reaches them blindness, which may be permanent, results. The bite of the ringhals is highly venomous, but the snake appears to prefer disabling its enemy by means of the spray of venom.”

The most novel and interesting of Mr. Scully's contributions to African herpetology, however, is his story of the mamba (*Dendraspis angusticeps*), which he calls “the head of the family.” It is the longest venomous snake in the world, probably

running to fifteen feet in exceptional cases, but is slender and primarily a tree snake. This naturalist declares it to be the most dangerous of all snakes, as it is highly aggressive at times and its speed is quite extraordinary. If disturbed during the pairing season, the mamba attacks without hesitation; and if at any time one happens to get between the mamba and its dwelling, the snake rushes straight for its objective and, in passing, strikes swift as lightning at the intruder. It progresses in a series of bounds, suggestive of the successive uncoilings of a steel spring. There are two varieties, one colored a vivid grass-green, the other steely black, both so dreaded that the news that a large mamba has been seen will cause the vicinity to be shunned—perhaps for months.

“The mamba has the habit of lying coiled among the branches adjacent to a footpath in a forest. Woe to the passing wayfarer in such a case! If he touch a twig, and thus impart the least tremor to the snake’s lair, a lightning-swift stroke upon face, neck, or arm seals his doom. Such a stroke may be delivered either forward or sideways, with equal speed and effectiveness.”

The most feared of the cobra tribe in India and eastward is the king cobra, or hamadryad, which often exceeds a dozen feet in length and is “the largest, boldest and most dangerous of all venomous snakes,” in Boulenger’s opinion, “for when disturbed it does not content itself with merely sitting up and expanding its hood, but will almost invariably attack.” Fortunately it is not numerous anywhere in its range from the Himalayas to the Far East; and it is useful in that it feeds exclusively on snakes, small pythons, kraits, rat snakes,

and the common cobra. Its bite will kill a man in an hour or two; and it is recorded that an elephant bitten by one died in three hours.

Nearly all the serpents of Australia belong to Elapinae, and are exceedingly dangerous. Among them are the "black snakes," the females of which are called "brown adders"; the "tiger," so called from its colors; and most dreaded of all, the "death adder," which is distinguished by a peculiar tail end, and by the fact that the head is made distinct from the body by a narrow neck, giving it a viper-like appearance. When disturbed it flattens out the whole body.

A few words about the sea snakes will close our account of the poison-bearing colubrids. These are set apart in the subfamily Homalopsinæ, on account of the structure of the tail, which is flattened vertically into a combination of swimming organ and rudder, for they live in the estuaries of Oriental rivers, and go far out to sea in their search for food; and are to be met with from the Persian Gulf to Polynesia and Japan. All are very poisonous, feed mainly on fishes and produce living young; and all are clothed in varied and brilliant colors. Living in the sea, or in tidal inlets, their movements in the clear blue water are agile and elegant; and in the Bay of Bengal they are sometimes seen congregating in large shoals.

We turn now to the last and most advanced family of serpents, the vipers, rattlesnakes, moccasins, copperheads, and so forth (Viperidæ).

#### VIPERS, MOCCASINS AND RATTLESNAKES

"Viper" is an old French-Latin word, meaning "bearing living young," which was noted as dis-

inctive from the egg-laying habit of other snakes, and peculiar to the single species that the people of southern Europe knew—the small *Vipera verus*, or asp, from which the large and widespread family derives its name. The vipers differ from the colubrids in important particulars. Their bodies are thick in proportion to their length, which rarely exceeds six feet, and this and their weight make them unable to run rapidly or (with one exception) to climb trees. The sturdy body narrows into a slender neck supporting a distinct head, given a flattened, triangular form by the expansion of the hind head on each side to accommodate the great poison sacs with which these snakes are provided. The maxillary is a stout bone in the fore part of the upper jaw, and carries on each side a long, backward-curved fang, which is tubular and is connected at its root with the extremity of a duct from the poison sac. When the serpent's mouth is closed, or it is swallowing anything, these fangs, which in a large snake may be an inch and a half long, lie back in a fold of the flesh out of the way; but when the mouth is widely opened they spring forward, and when the head is darted forward to strike a prey or an enemy, they are driven down into its flesh and the venom spurts through them into the wound, with benumbing and deadly effect. They are frequently broken or dragged out, and then new ones arise from behind to replace them. The eye is large, dull, and catlike in its pupil; the scales are strongly keeled and dull in hue in the desert dwellers, but often gay with colors in intricate patterns in the forest dwellers; and the short and stumpy tail may end in "rattles," or a horny tip, or neither. Nearly all give birth to

large broods, which are as vicious at birth as are their mothers. The family has two sections, marked by the absence in the first, and the presence in the second section, of a deep pit in the broad scale on the head between the nostril and the eye.

The original little "viper" of Europe and Asia is more a nuisance than a peril, for it is rarely more than a foot long, and its bite would be fatal only to a small child. A larger species, the sand viper, ranges from Italy to Armenia. India, Burma and Siam, however, have a member of this group which is pronounced by Sir J. Fayrer as next to the cobra the most dangerous serpent of the East—the daboia, or Russell's viper. It is nocturnal, not aggressive, and makes a loud hissing when anyone comes near it, so that it does not cause as many human deaths as it might; but frequently kills grazing cattle by biting them on the nose. The greatest and worst of these snakes belong to Africa, where the northern deserts are infested with two greatly dreaded species—the horned and the saw vipers. The former has two sharp hornlike protuberances above the eyes, and Canon Tristram writes that its usual habit is to coil itself on the sand, where it basks in the impress of a camel's footmark, and thence suddenly to dart out on any passing animal. Horses as well as men are in constant terror of it, for it will attack without any provocation.

The worst of the African vipers, nevertheless, is the puff adder, which ranges over the whole continent, and may grow to a length of six feet, with a girth equal to a man's thigh.

"The coloration of the puff adder," Mr. Scully writes, "is in groundwork a series of delicate browns, with more or less regular curved trans-

verse patches darkening to black and edged with vivid yellow. Its scales are keeled; its short tail tapers suddenly to a point. It is a sluggish creature, incapable of swift progression. When disturbed, it flattens itself to the ground, the air expressed in the process causing the warning hiss which has saved many a life. But if the foot of the intruder touch it, or even tread in its immediate vicinity, the puff adder lunges either forward or sideways, with a swiftness that the human eye cannot follow, and, having buried its fangs deep in the flesh, holds on like a bulldog, forcing two streams of venom into the tissues. The expression of this snake—its square muzzle and glaring, lidless eyes with vertical pupils—the extraordinary gape of the jaws and the huge, erected fangs, form what is probably one of the most fiendishly menacing combinations in nature. Nevertheless, apart from its head, the puff adder is a creature of great beauty. The 'night adder' (*Causus rhombeatus*) is much dreaded on account of its habit of lying at night in pathways and failing to move out of one's way. This snake is one of the exceptions to the rule of the viper class, in that it is not viviparous. It has another remarkable peculiarity: the poison glands, instead of lying compactly embedded in the maxillary muscles above the angle of the jaw, are much elongated, and lie one on each side of the spine."

All the pit vipers are American except a few species in southern Asia, some of which are arboreal in habit and have red prehensile tails. Our American species fall into two genera: *Ancistrodon*, the moccasins (no rattles), and *Crotalus*, the rattlesnakes.

The "upland moccasin" of the South is the "pilot" or "copperhead" of the North, where it still exists in forested and rocky districts from Connecticut and the Great Lakes to Texas, and is particularly abundant in the rough hills beside the Hudson River, and thence southward along the Alleghenies. Its general hue is yellowish brown, becoming chestnut or coppery red on the head and end of the tail, which terminates in a hard point. Along the back, meeting irregularly on the midline, are chestnut-hued blotches that divide on the sides, forming inverted Y's; the belly is yellowish with distinct black blotches, leaving the throat clear. After one has seen a copperhead he is not likely to confuse it with the milk snake or any other. Its haunts and habits are much the same as those of the eastern rattlesnakes, nor do I consider it any more aggressive in spite of a rather over-blackened reputation, nor so deadly in the effects of its weaker venom. It is bad enough, however, and should be killed on sight wherever children or pet dogs are likely to meet with it. This upland moccasin is named in science *Ancistrodon contortrix*; its brother species, the water moccasin, is *A. piscivorus*.

The moccasin is a larger, heavier snake than the copperhead, and a dweller in the sluggish rivers and swamps of the Gulf States and northward to North Carolina and Kentucky. The moccasins commonly lie on the branches of bushes at the edge of the water; and if escape from danger be possible they quickly drop into the water and swim away beneath it to some hiding place. If suddenly surprised they coil and open the mouth widely toward the intruder, showing its white interior that has given them the name "cotton mouth" among the

darkies, who fear them greatly, especially as they work in the rice fields. Mexico has a similar species.

Closely allied to the copperhead and moccasins are two very dreadful snakes of the American tropics—the “fer-de-lance” of the French islands of the West Indies, and the “bushmaster” of Brazil. The former reaches a length of six feet, and the bushmaster, or surukuku, as the Indians name it, to twice that length, thus rivaling the great viper of India. Both have all the ferocity and power of their race exaggerated to the limit, and hundreds of human lives are sacrificed to them every year. Every traveler has thrilling tales about them. Leo Miller, a cool-headed man of science, takes very seriously the fear this creature inspires. He reminds us that a bushmaster ten feet long has fangs an inch and a half long, and injects nearly a tablespoonful of poison at a single thrust. A man would survive such a dose but a few minutes. When once a bushmaster fell from a tree branch into his canoe everybody in it sprang overboard, and some narrowly escaped drowning. Such deadly creatures would make the tropical world unendurable were it not that most of the time they are sluggish and peaceful; but a little fright, or a protective instinct in regard to their eggs, sets them off with the suddenness of a released spring.

In taking up the rattlesnakes we have a sure guide in Dr. Leonhard Stejneger’s “Report,” describing all the species of North America (the group *Crotalinæ* is confined to this continent, Central America, and a single species in South America). The special peculiarity of the group is the queer “rattle” (*crotalus*) at the end of the tail. This consists of a series of loosely connected, somewhat cone-shaped, horny

capsules, each of which originally covered the terminal vertebra of the tail. On sloughing the skin this covering remains, but is soon pushed away by the new capsule formed beneath, and partly within it, which in turn is pushed out and replaced by a third, and so on, until sometimes a dozen remain linked together; and when the serpent vibrates its tail, as most snakes do when excited, they rattle against one another, the tone of the "music" rising as the excitement, and speed of vibration, increases. The sloughing is irregular as to frequency, however, especially in young individuals, and may not always produce an addition to the rattle, and the appendage itself may be broken, so that the number of pieces, or buttons, in the rattle is not a trustworthy measure of the age of the snake.

The smallest of the crotalids are the ground rattlers (genus *Sistrurus*), of which we have two species, and there is one in Mexico. The northern kind, widely known by its Indian name "massasauga," ranges from eastern Pennsylvania and Ontario to northern Minnesota and Kansas, and thence to Texas. The Southern States have a second species commonly called "ground rattler." Both are grayish brown with chestnut or darker dorsal blotches, and are inhabitants of the prairies, with their swamps and marshes. The largest do not exceed forty inches, and their bite is correspondingly weak in effect.

The remainder of the rattlesnakes belong to the genus *Crotalus*.

The commonly seen species of the region east of the dry plains was named *Crotalus horridus* by Linnæus, and this is one of the few instances in which his name has defied change by the systemists. It

formerly was to be found as far east as central Massachusetts, but there, as elsewhere, civilization has killed it off, so that now it survives only in the Appalachian glens, and in thinly settled tracts farther west and south. Its general color above is yellow-brown, below nearly white; and the body is banded with blackish, the bands taking a zigzag form behind the neck, and the tail is black. It rarely exceeds a yard in length, and is, as a rule, timid and nonaggressive; but a good deal remains to be learned about its habits and breeding.

Far more formidable than this is the diamond-back (*C. adamanteus*) of the low, coastal region from North Carolina to the lower Mississippi River and throughout Florida, where it is far more common than is desirable. This rattler may exceed eight feet in length, and has corresponding power of harm. It is partial to the neighborhood of water, where its ground-running prey is most numerous; hence it is frequently spoken of as the "water rattlesnake," to distinguish it from the banded species, or "timber rattlesnake" of the same region, which is more habituated to forested districts, with rocks. A race of *C. horridus*, usually large and vicious, exists in the coast swamps, and is locally called the "canebrake rattler." The diamond back itself takes its name from the lozenge-shaped patches of dark color formed on its upper surface by the crossing of diagonal narrow bands of bright yellow on a greenish gray ground. The literature relating to this terrifying snake would fill hundreds of pages. Raymond L. Ditmars of the New York Zoölogical Park, gives this description:

"Most deadly of the North American poisonous snakes, and ranking in size with the largest of the

tropical venomous serpents of both the New and the Old World, this huge rattlesnake, with its brilliant and symmetrical markings, is a beautiful and terrible creature. Ever bold and alert, ever retaining its wild nature when captive, there is a certain awe-inspiring grandeur about the coil of this formidable brute; the glittering black eyes, the slowly



THE RATTLESNAKE  
(*Crotalus horridus*)

Beside the snake is the skin it has just discarded

waving tongue, and the incessant, rasping note of the rattle. . . . The mere vibration of a step throws the creature upon guard. Taking a deep inhalation, the snake inflates the rough, scaly body, to the tune of a low, rushing sound of air. Shifting the coils to uncover the rattle, this is 'sprung' with the abruptness of an electric bell. There is no hysterical striking, but careful watching, and if the opportunity to effect a blow with the long fangs is presented, the result is generally mortal."

A large and very showy western analogue of the diamond-back, known by the sinister specific name *atrox*, occurs from central Texas to California. One of its varieties is red, with darker red markings and a white tail. The familiar rattlesnake of the plains east of the Rocky Mountains is *Crotalus confluentus*, which is of moderate size and dull hue; its mainstay of food is found among the prairie-dog towns. A similar but smaller species (*C. oregonus*) takes its place west of the Rockies, from British Columbia to southern California. The "tiger" rattlesnake, yellow barred with black; the "horned" rattler, which, like the Egyptian horned viper, has a trick of advancing sidewise, and consequently has the popular name "sidewinder"; and the slender green rattlesnake, are small species of the deserts along the Mexican border.

## CHAPTER XXII

### BIRDS—KINGS OF THE AIR

**A** BIRD is an animal clothed with feathers and having the forelimbs adapted to flight.

The birds constitute a class in the phylum Chordata, and otherwise are combined, in the group Sauropsida, with the Reptilia, with which they agree more closely in anatomy than with any other group, one prominent particular being that both have a single condyle, in contrast with the mammals and amphibians where the condyle is double. In fact primitive reptiles—probably of the stock of dinosaurs—are the ancestors of birds, the divergence having occurred probably in Carboniferous time. Of the earliest divergent forms, the rocks have as yet yielded no specimens, the most ancient bird forms recovered showing a degree of development in the new type that must have been preceded by a long history of evolution from its reptilian source.

The oldest fossil bird known is that named *archæopteryx*, whose remains are found in the Jurassic slates of Bavaria, which represent the beginning of the Mesozoic or Age of Reptiles. In much of its anatomy, and in the possession of perfect feathers, it is a true bird, yet it retains many reptilian features. Its body was about the size of a small crow; its legs were rather long, with well-developed feet of four toes suitable to grasping a

perch; its wings were short and probably feeble, for the shoulder girdle and ribs are weak and the sternum is rudimentary. It is plain that it was arboreal in habits, but a poor flyer, and was aided



#### ARCHÆOPTERYX

Skeleton of *Archæopteryx macrura* with indication of feathers  
(Reconstructed. After Andrea)

in scrambling about the branches of trees on whose leaves and bark it may have fed, by the fact that three digits of the rather lizardlike wing hand

terminated in strong claws, while the thumb was entirely free.

The practical value of this clawed hand is illustrated in a living bird—the hoatzin, of northern South America—which exhibits in several ways the probable appearance and manners of the archæopteryx. “It haunts the sides of lagoons and rivers where a thick growth of low trees projects over the stream or the mud left bare by the tide. When disturbed the bird flies off awkwardly with a violent flapping motion, or leaps from bough to bough, erecting its crest and expanding its wings and tail. The note is sharp and shrill, and has been described as a hissing screech. The food consists of leaves and fruit. The conspicuous nest, placed on low trees or shrubs, is a loose platform of spiny sticks and twigs with a softer lining, and contains from three to five yellowish eggs, spotted with reddish brown and lilac. The young, which can see and run as soon as they are hatched, have a claw on both forefinger and thumb, by means of which they creep about the thickets, and hook themselves over the branches, assisted by the bill and feet. They can also swim and dive.”

The most striking features of the archæopteryx were its head and tail. The skull is fairly avine, and the rather short and blunt bill was furnished with conical teeth, nearly equal in size, and set in a marginal row in distinct sockets. Still more lizardlike was the tail—a prolongation of the backbone nearly as long as the body, along each side of which sprouted strong feathers forming a horizontally flat tail with a rounded end.

The next that we know of bird evolution is derived from the discovery of the fossil remains of toothed

birds in the Upper Cretaceous formations of Kansas—that is, in the more recent half of the Mesozoic Age. They differ greatly not only from archæopteryx but from each other, and are represented by



TOOTHED BIRD  
(*Hesperornis regalis*)

Skeleton of toothed bird (After Marsh)

several species. One type (*Hesperornis*) was a wingless, diving bird of great size, whose long, heronlike beak was studded with small, sharp teeth, all alike, implanted in a continuous groove; its legs were so hinged to the compressed pelvis that they could be extended almost level with the back, and the lobed toes thus became lateral winglike paddles

of great power. The other type, represented by *Ichthyornis* and its relatives, also had a long, stout bill set with teeth, but each in a separate socket. *Ichthyornis* was about the size of a pigeon, and its strongly developed wing bones and deeply keeled sternum show that it was a bird of powerful flight, and apparently gull-like habits. So far as we know neither of these Cretaceous birds had any progeny. When, after an immensely long period, other fossils come to light in rocks of the middle Tertiary period they bear few traces of ancestry, and exhibit little relation to the great mass of modern orders. They are the "flightless birds," possessing no wings but running about on massive legs; and the group includes the extinct *æpyornis*, *dinornis*, and *moa*, and the existing ostriches, rheas, emus, cassowaries, and kiwis. Some ornithologists question whether this "ratite" group, characterized by having no "keel" on the sternum, did not have an origin and line of descent quite distinct from those of both the Cretaceous toothed birds and the modern "carinate" type which possess a medial crest or "keel" on the breastbone for the support of the flight muscles; but the more general opinion is that they are a variant from very early birds with wings.

#### HOW A BIRD IS BUILT

Since its feathers are the one thing that marks a bird, outwardly, as different from other classes of animals, we ought first of all to learn what feathers are, and what purpose they serve. A quill feather, such as may be picked up in any farmyard, has a horny, hollow stem or "shaft," which is bare at the closed large end or "base," but has two soft, winglike expansions toward its tapering end that

together make its "vane." This thin, flat vane consists of delicate branches, "barbs," studded with tiny hooks, the "barbules," holding each adjacent branchlet in place, but letting the whole vane bend and spring. The whole beautiful thing is really very strong and elastic, as it must be to push as hard against the air as a bird's wing has to do. The vanes vary much in shape, and in the degree to which the branchlets are disconnected into a fluffy looseness. Ostrich plumes, and those of the birds of paradise, owe their beauty to the fact that each branch in the vane is loose, and bears little disconnected branches of its own; and in many feathers no vane at all grows, so that they resemble hairs, when fine, and bristles when coarse, as is seen about the mouth of the whippoorwill and some flycatchers. The nestling plumage or "down" is of this character. The lovely plumes of egrets are slender stems of feathers having in place of a vane scattered soft hairs. In some sea birds the feathers are so stiff and hard as to be almost like scales. Those of water birds, and especially the divers, are wonderfully close, thick, and greasy, so that the down that forms an undercoat for warmth, and the skin beneath it, never get wet.

Feathers, then, serve their wearers first of all as clothing—very thick and warm in birds of cold places; and doubtless this beneficial modification of the primitive reptilian scale, by reason of its conserving the warmth of the body, and gradually increasing the temperature of the blood, has been largely instrumental in enabling birds to rise so far above the grade of their cold-blooded and sluggish ancestors.

Most animals whose lives are spent in the open air and light show more or less color in their coat, but none are more beautifully adorned than birds. The most brilliant examples are to be found in the tropics, and some of the gayest in our colder land, such as the tanagers and humming birds, are strays from large tropical families noted for gaudy attire.

The color we see in plumage may be due to either of two conditions. It may, as is usually the case, be simply coloring matter deposited in the substance of the feathers. But where the plumage gleams with changing rainbow lights, as on the fiery throat patch of the humming bird, on the neck of a dove or on the purple-black coat of the grackle (crow blackbird), these splendid reflections are caused by very minute wrinkles on the feathers, that break up the light. It is the same effect, called "iridescence," as is seen on the mother-of-pearl and on a soap bubble. Blue is usually an effect produced by certain coloring matter not blue underlying a thin covering of feather substance; and when you pound a blue feather into dust that dust will be black or gray—or, at any rate, not blue. Birds of the same group are colored much alike, as a rule.

In some cases the style of colors worn appears to be the best for the safety of the birds of the group by making them hard to see as long as they keep still. Thus most birds whose lives are passed on or near the ground, and which build their nests there, are dull in coloring; they are in danger from more enemies than are tree-dwelling birds, and must be able to hide better. No bird of nocturnal habits is brightly colored. It is mostly among the small, quick-flying species, such as warblers and finches,

that we find the gayly dressed ones. They are birds of the sunshine, and usually migratory. In most cases when birds have a plain dress there is little difference in it between the male and the female; but whenever you find a species of bird wearing a gay, ornamental dress, it is almost always the male that sports these fine feathers, while the female and young are clothed in dull yellow, drab or brownish tints. This appears to be another measure of safety. The males can wander about, look out for themselves, and take to flight when danger threatens; but their mates must sit quietly on their nests, and trust for safety for themselves and (what is really more important) their eggs or young mainly to not being seen. In their plain colors they blend into the foliage and the shadows amid which they sit, and so are more likely to escape the sight of prowling foes.

Feathers are not intended to remain permanently; they become worn and faded, or are lost, so that at regular intervals the bird needs a new suit of clothes. Twice a year, therefore, in spring and autumn, they are pushed out by new ones sprouting in the same feather-growing pits. This shedding of the feathers is called "molting," and it is analogous to the shedding of the outer, horny pellicle of its skin by a snake or lizard. Their molting is not very noticeable in land birds, because the feathers drop out little by little; otherwise the poor creatures would be left quite naked, and unable to fly. In most birds the new feathers that come in are the same in pattern and color as those they displace, so that the new plumage differs little if any from season to season; but some birds acquire a new coat for winter that is decidedly different, and sometimes snowy white, making them inconspicuous amid the snow.

The largest and most important feathers in a bird's outfit are those of the wings and tail, by means of which it flies and controls its progress. How birds are able to keep themselves aloft in the air, and move through it at will, is not yet understood. That it requires great strength of wing muscles, and rigid support for them is evident. Therefore we find the head of the arm bone (humerus) fastened by stout ligaments to a great shoulder blade sunk in the flesh beside the fore part of the spine, and also braced in two directions by other interior bones, one of which extends down to join its opposite fellow at the front end of the breast bone, and form the "wishbone" (the united coracoids). This solid bracing by bones and tying by ligaments gives the needed firmness to the wings; and enables their powerful muscles to work them.

How great these muscles are you will know when I tell you that the thick mass of "white meat" in the breast of the fowl carved at your table consists only of the two principal muscles that move the wings when a downward stroke is made. They, in their turn, are attached at the base to the broad surface of the breastbone, or "sternum" and its projecting keel. Beyond the wrist joint stretches a large, misshapen hand, which consists mostly of one great forefinger, in the tough flesh of which the big quills, or outer flight feathers, called "primaries," are rooted. Lying over their bases, when the wing is folded, is a row of somewhat smaller quill feathers called "secondaries." Above those are the small and close "wing coverts."

The tail is very important in guiding and checking a bird in flight, and is useful in various other ways, and may also be extremely ornamental. The tail

quills are always in pairs, making an even number of feathers. This results from the reduction to a mere stub of the long clumsy tail worn by the archæopteryx and its fellows. The quills continued to grow in pairs out of the side of the tail as it diminished until all that there is room for (ten or twelve pairs) are now rooted side by side around the edge of the condensed coccygeal bones.

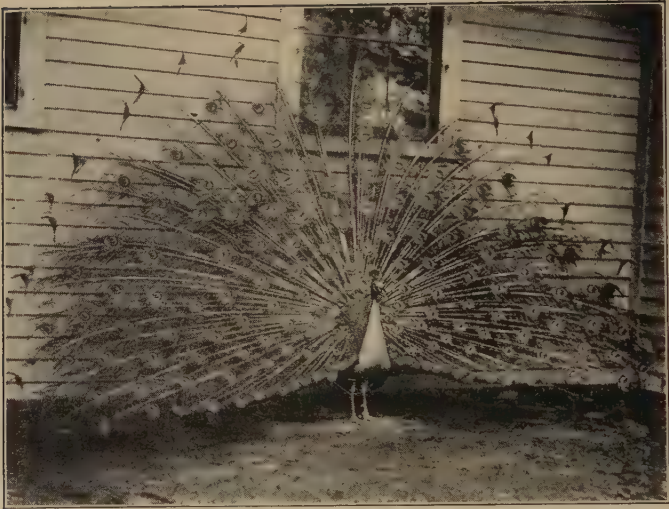
Birds are, as a class, the most active of animals, and their temperature is highest; this means a large consumption of oxygen, and the windpipe is usually capacious, yet the lungs are not large, but are supplemented by another apparatus for aeration. Opening out of the lungs are several pairs of air sacs, amplest in those birds that are much on the wing, which not only occupy spaces between the muscles and organs within the chest, but in many cases extend into the neck and head, and even into the limb bones, which in most birds are hollow.

Here is a suitable place to say a few words about how a bird sings. The breath enters and leaves the windpipe through the larynx in the back of the mouth—an organ which, in our throats, contains the vocal cords and voice-producing apparatus; but in birds the larynx is unimportant, for their voice organ is near the lower end of the windpipe, and is called “syrinx” or music box. It consists of an enlargement and modification of the bony rings about the windpipe at the point where it forks into the two branches to the lungs; and incloses vibrating membranes. It is also furnished with small muscles that act to expand or contract the tube and its inner fixtures, thus regulating the column of air forced through the syrinx when the bird calls or sings. These muscles thus control the space and the shape

THE PELICAN, NOTABLE FOR ITS THROAT POUCH

Photo, Keystone View Co.





Photo, Keystone View Co.

PEACOCK WITH BRILLIANT TAIL SPREAD



Photo, A. N. Muzaff

SACRED PHEASANT

of the opening, and the tension of the membranes that serve as vocal cords. The muscles of the syrinx vary greatly in number and efficiency among birds; and many kinds classed as "singing birds" (Oscines) do not sing melodiously or tunefully because their music box is imperfectly supplied with the proper muscles. They have the instrument, but are unable to play upon it.

The 10,000 or more different kinds of birds now living in the world are classified in fifteen orders, of which the lowest in rank is that of the ostriches, and allied ratite birds, mostly extinct, that stand in a place apart by reason of their archaic structure and inability to fly. The ostrich is still wild in the arid districts of Africa, Arabia, and Mesopotamia; the rhea is Patagonian; the emus and cassowaries belong to Australia and New Guinea; the apteryx, or kiwi, still survives in New Zealand; and several gigantic ratite birds have recently become extinct in New Zealand and in Madagascar, where egg shells, laid by the prehistoric *æpyornis*, that will hold two gallons are still found. Some species of these birds were seven feet in height.

## CHAPTER XXIII

### SOME NOTABLE WATER BIRDS

FROM these relics of geologic antiquity the remainder of the birds now living, and their fossil ancestors as well, differ fundamentally, and are united in a division whose badge is the keel on the sternum; hence they are termed "carinate" birds (*Carinatae*). The list begins with the most archaic order, that of the loons, of which three or four species are named, but they are hardly separable. They are as big as geese, have black backs checkered with white spots, white undersurfaces and heads purplish black, variously marked; and these heads and necks have a very reptilian look, as they stretch forward their heads inquiringly, or utter the "wild laughter" that seems so consonant with the lonely waters they frequent. The reptilian suggestion is even stronger in their cousins the grebes, known to gunners as "die-dappers," "hell-divers," etc., on account of the quickness with which they will disappear when alarmed. The family badge is on the feet, where the toes are not connected by a full web, as in loons, but every toe is margined by a flange of firm skin with a scalloped margin. Grebes have a way of swimming with the whole body under water, when the exposed head and neck look very "snaky." The brown and white plumage of grebes is exceedingly close and dense, and their indifference to wet and cold is shown by the fact that their nests

are mere rafts of sodden weeds often so loosely tied to the rushes that they go adrift. Grebes abound on all northern waters and are rarely shot since the taking of their silvery breasts for hat ornaments has been stopped.

The penguins constitute an order limited in range to the antarctic region. Their picture is in everybody's mind—a bird that stands as erect as a soldier on two almost invisible legs and a short stiff tail, and carries a small head, sometimes plumed, with a strong pointed bill. The picture usually represents the great flocks that resort in the brief summer to their rocky breeding places on icy shores, each female guarding and incubating her two eggs in the rudest of nests on the ground. These antarctic "rookeries" sometimes hold tens of thousands. During the rest of the year the penguins are at sea, or under it, behaving more like seals than birds, for their scalelike plumage is impervious to water, and their stubby wings are in effect flippers by which they swim under water, the strong-webbed feet acting only as rudders until they come to the surface and can paddle. Penguins feed on crustaceans and mollusks mostly, but also on fish and sea weed.

Next comes that group of wide sea wanderers, the albatrosses and petrels, united in the family Procellariidæ, whose special mark is found in the two bony tubes along the top of the beak that contain the nostrils. Of the albatrosses many species are known, nearly all inhabitants of the southern oceans, although two or three of the largest regularly visit the North Pacific coast, and more rarely one strays into the North Atlantic; certain small species frequent the western coast of South America. The one best known is the "wandering" albatross, whose

wings spread nine or ten feet, yet are only nine inches wide. They spend their whole lives on the open ocean, and undoubtedly sleep there, regardless of storm or calm; but in summer land on some lone antarctic island or lofty shore, and construct a heap of mud and rubbish on top of which they deposit two chalky eggs.

Their relatives, the oceanic petrels, are much smaller as a rule, and some no bigger than sparrows. They are of many kinds, including fulmars, shearwaters, etc., and nearly all are black or sooty brown, usually with touches of white. Most of the group are denizens of the southern hemisphere, but some belong to the north and are migratory; and the eastern Atlantic and Mediterranean are the home of the original stormy petrels, which sailors call "Mother Carey's chickens" and regard with mingled superstition and affection; Leach's white-rumped petrel, of our New England coast, shares this name. Some of the far-southern species are almost as big as albatrosses. Petrels get their food from both the waves and the shore and follow ships on long voyages in hope of scraps of flesh thrown overboard. Most of them breed in holes dug in the topsoil of sea-fronting cliffs, and lay white eggs; many hide in these holes by day, and go out only at night, filling the air with wild cries while they hunt; but fulmars and shearwaters, which make rude nests on rough shores or on cliff ledges, often in vast colonies, go abroad in daylight, and throng on the Grand Banks and wherever else fishing is going on.

Next, in the classification based on structure rather than on superficial resemblances, comes a large assemblage of water birds, some exclusively marine, others of inland waters. Here are placed

those long-winged, graceful, oceanic flyers, the tropic birds, and the many kinds of gannets, snowy white, that soar and plunge like falcons as they sweep over the waves and pick up incautious squids, fishes, etc. Most of them are tropical, but one gannet is well known on both shores of the North Atlantic where it nests in thousands on the cliff faces that bound such lofty islets as the Bass Rock near Edinburgh, the Hebrides, and Bird Rock in the Gulf of St. Lawrence. The flight is easy and powerful, and the food is caught by a hawklike plunge.

The nearest relatives of these white birds are the cormorants, which are shining black, glossy, with blue or green reflections. They are scattered over the whole globe, most of them along seashores, but many breed on inland lakes and swamps, usually in large companies. Unlike the sweeping and beautiful flight of the far-wandering gannets, these birds appear heavy on the wing; and instead of snatching their food from the surface they dive after the fishes on which they feed, and pursue their slippery prey under water, swimming with both wings and feet, and dodging here and there in a most surprising way. Their bills are peculiarly well adapted to holding what they catch; and a near relative of the West Indies and southward often spears its prey with its bill. This is the darter or snakebird, so called because its long neck and small head give it a peculiarly snakelike appearance as it swims with nothing above the surface but the slender head, and that making scarcely a ripple.

Far more of a wanderer is the tropical long-tailed, long-winged, black frigate bird, which is the hawk of the sea, for it hovers about the flocks of fishing birds and forces them to disgorge their

catch, which it appropriates as it falls. Among the birds that suffer most from its robberies are the pelicans, several species of which live close to salt water in various parts of the world, while others prefer the lakes and swamps inland. We have two common species in the United States, the white pelican, seen all over the interior of the country in summer, and the brown, which is southern and maritime; both are gregarious not only in their annual migrations but in their breeding, building nests on bushes in large companies. Their food is mainly fish, caught both by diving and by scooping them up as they swim. The well-known peculiarity of the pelican is the bag of naked skin that hangs from the underside of the bill, and serves as a receptacle for the catch; when it is filled the bird returns to its resting place to consume its food at leisure, or to open wide its mouth and allow its nestlings to pick out the contents of the bag.

All the foregoing are mainly marine and have short legs and webbed feet, used principally in swimming; but we now come to the fresh-water "waders"—the herons, bitterns, storks, ibises, and the like, whose bodies are perched on stiltlike legs, and whose habits require them to wade about in marshes and swamps in search of their miscellaneous food; hence the neck also is long and the bill straight and sharp-edged to fit it for seizing and holding the active prey by a sudden thrust. All warm and temperate countries possess herons in a great variety of species, varying in size from a bird three and one-half feet long, such as our great blue heron, to one a few inches only in length; but the colors are usually light and prevailingly bluish or greenish; while the marsh-loving bitterns are

streaked brown. Some are pure white, as is our elegant egret, which has been all but exterminated in the United States by men who kill it in the breeding season, when the beautiful plumes that then adorn its back are at their best, and are marketable as ornaments for hats and military shakos. Every plume bird so killed means the loss of a family of young. Herons are shy, solitary birds, as a rule, nesting on trees in remote swamps in "rookeries" to which they return year after year from their winter retreats in the tropics; and they get their food, which includes every sort of living thing they can find, mostly by standing motionless in the water until it comes near enough to be picked up by a swift stroke.

The storks are similar birds, but with rather heavier bodies and a way of standing erect, and of holding the head straight out in flight (the herons draw it back by curving the neck), which distinguishes them. They are white and black as a rule, and mainly Oriental or African, no typical species occurring in the United States. Storks are more inclined to search the land for food than are the herons, and an Egyptian species is locally called "a bird of blessing," because it cleans the villages, while the stately "adjutant" of India is carefully protected as a similar scavenger. The most familiar of the storks, however, is the white one that in Europe nests on the roofs of houses, chimney tops and similar places, and is generally regarded with an affection that has been expressed in many a poem and story. Ibises are much like storks, the common "sacred" ibis of Egypt probably owing its religious distinction to its fondness for lizards and snakes—a service highly appreciated in that coun-

try. Several ibises inhabit America, one of which is not uncommon along the border of the Gulf of Mexico, while another is noted for the splendid scarlet of its plumage. In the same family is the beautiful spoonbill of our Gulf Coast, whose name



FLAMINGOS

(*Phenicopterus ruber*)

refers to the spatulate expansion of the end of the beak. Its richly roseate hue is reproduced in the dress of the flamingos, that need not be described.

We pass from the flamingos to the ducks by an intermediate form—the curious chahas and horned screamers of northern South America—large, turkeylike birds, often tamed and made of service

on country places, where they guard the poultry against hawks and other enemies.

The ducks are a cosmopolitan family (*Anatidæ*) of about 200 species, divisible into five groups, namely, mergansers, river ducks, marine ducks, geese and swans. These have many features in common, one of which is that in the early autumnal molt all the wing quills drop out at once, so that for a time none of them is able to fly. The mergansers, sheldrakes, or "saw bills," are fish eaters, catching their prey under water, where they move expertly, by means of the narrow, tooth-studded bill that reminds us of the *ichthyornis*. They frequent rivers, and most of them prefer rushing streams. Of our three species two breed only in the Far North, the third on the Pacific slope. During the winter they resort to a marine life in warmer latitudes. The river ducks (*Anatinæ*) are distinguished from the seafaring ducks (*Fuligalinæ*) not only by their preference for inland lakes and marshes, but by the fact the hind toe bears no lobe, while in the sea ducks it is somewhat webbed and functional. This group includes such well-known species as the mallard, black duck, gadwall, widgeon, baldpate, teals, shoveler, pintail, and the exquisite wood duck, to speak of American species alone. The mallard and wood duck breed all over the continent, the latter having the peculiarity of making its nest in trees, but the others rarely nest south of Canada, except among the mountains of the Pacific slope.

The seafaring ducks in North America also include several species that are found on inland bays and salt marshes, such as Chesapeake Bay and its borders, and do not limit their migratory routes to the seacoast, but fly overland. Such are the

redhead and canvasback, the scaups and golden-eyes and the ringneck; but the eiders, the scoters, and some others are truly oceanic. Most of these breed in the Far North, always nesting on the ground, as is the rule of the whole family, except the golden-eyes, which choose hollows in stumps and trees. None of the ducks lays spotted eggs.

While among the ducks the male is likely to wear, at least in the breeding season, more gayly colored plumage than the female—often of extraordinary beauty—among the geese both sexes are alike, and either white throughout, as in most of our species, or brown or gray, with more or less black, as in the brants, and in our common “wild” or Canada goose. Geese are far more terrestrial than ducks and visit the land to nip the herbage, young corn, or cereals; in California doing serious damage to growing crops. All our species breed in arctic lands except the Canada goose, which still makes its nest in the northern parts of the United States and throughout Canada; and most of them spend the winter south of our country. They represent to most persons the idea of bird migration. “We see the living wedge of long-necked birds,” says Chapman, “passing high overhead; the unbroken sound waves bring the sonorous ‘honks’ with unexpected distinctness to our ears; and we receive an impressive lesson in the migration of birds. They are embarked on a journey of several thousand miles, but they come and go as surely as though they carried chart and compass.”

As these geese are larger than the ducks, so the swans surpass the geese in size and are indeed the largest of water birds. The eight species are distributed all over the world, everywhere frequenting

fresh waters alone; and all are white except a black-headed Argentine species, and the wholly black swan of Australia. Before the discovery of this Australian curiosity a black swan was the proverbial *rara avis*—something incredible! Swans live mainly on weeds and roots pulled up from the bottom, but also eat snails, and so forth. Two species, the whistling and the trumpeter swans, belong to the American fauna, but both are now rare.

## CHAPTER XXIV

### VULTURES, FALCONS AND GAME BIRDS

THE so-called "birds of prey" include three quite distinct groups, the American "vultures," the hawk and eagle tribe, and the fish hawks. All agree in having strong, hook-pointed beaks, in many cases with a toothlike point on the cutting edge of the upper mandible, and covered at the base by a fleshy "cere"; and in having claws of great strength termed "talons." This catlike armament, adapted to seizing and holding living prey, and tearing its flesh, indicates the predacious nature and practice of the tribe, but it is developed to its fullest extent only in the falcons and powerful eagles, since a large part of the order are carrion-feeders or catch nothing larger than grasshoppers. Among the carrion-feeders are the condor of the Andes, and his almost extinct cousin the California condor, which are the largest flying birds in the world. Near relative to them are the turkey buzzard and carrion crow of our Southern States, besides some tropical species. The vultures of the Old World are, as a rule, big birds inhabiting mountainous and desert places, and capable of overcoming almost any disabled or weak animal. A small one that in North Africa plays the rôle of town scavenger, as does our turkey buzzard, is famous under the Egyptian name of "Pharaoh's chicken." The partial nakedness of the head, often accompanied by a

great neck-ruff, is a characteristic of all these birds.

The lammergeier of the Alps and eastward to India connects in its structure and habits the vultures (*Vulturidæ*) with the real predatory family (*Falconidæ*), in which are placed the hundreds of species of buzzards, harriers, hawks, eagles and sea eagles, that subsist by killing and eating every kind of creature that it is within the power of each one to overcome. The bulk of their prey consists of small rodents; and in pursuing them they rid the land of vast numbers of little gnawers most injurious to agriculture; it should be the business of every farmer and orchardist to learn to recognize the three or four fierce little poultry-catching falcons in his locality, and refrain from killing any other sort of hawk.

It is a hopeless task to give any detailed description of the game birds, which are world-wide in their distribution and practically of the greatest importance to mankind, for in this group are found the originals of our domestic poultry (the jungle fowls of India), and the quails, partridges, grouse, pheasants, turkeys, curassows, and many more of hardly more interest to the naturalist than to the sportsman. The sportsman is willing to count the toothsome rails as "game" when he goes after them in the marshes of the middle coastal States. They are plain-colored birds that run about amid the salt grass and reeds, and are an interesting example of adaptation to this special station in life, for their bodies are notably compressed, so that a rail can slip through a narrower space than any other bird of its size; hence the proverb: "Thin as a rail." A common species in Europe is known in

literature as "corn crake"; and American relatives, the gallinules of fresh-water marshes, go by the name of "mud hens." The rails belong to the crane family, which includes many large tropical birds besides our own two kinds of cranes, both becoming rare in the United States.

Good sport and delicate fare are afforded also by the great tribe of "shore birds"—plovers, yellow-legs, curlews, snipe, and the various sandpipers that feed along the seashores or frequent the inland marshes of every part of the world, nowhere more numerous than along our much embayed eastern coast. The plovers are especially interesting, and one of them, the noisy killdeer, is familiar all over the country, breeding in upland fields, where four brown and spotted eggs are laid in a little hollow of the open ground, plover fashion. Another notable species, the golden plover, is a cosmopolitan, and a remarkable migrant, journeying from its arctic breeding place to the tropics, not only overland, but across thousands of miles of ocean, as from Nova Scotia direct to Bermuda, and Alaska to Hawaii. The crested "lapwing" of Europe is another famous species. The plovers have short bills and live on insects; but the sandpipers that in greenish or brown-streaked coats flit along the shores pick up a more miscellaneous fare from the edge of the sea and on exposed tide flats. Here, too, are the very longed-legged "stilts," the phalaropes with lobes along their toes like a grebe, the curlews, with their long, upcurved bills, the willets that alarm all the rest by their cries as soon as they espy a gunner, the big, gray godwits and many others. Various snipes form a group of small, swift fliers that haunt boggy land, where they probe the

mud with long bills furnished with nerves of great delicacy at the tip by which they can feel the hidden worms buried in the mud that are their favorite fare; and one of them is the swamp-haunting woodcock, beloved of gourmands on both sides of the ocean. Europe and Asia have several other kinds of birds in this class not known here, such as the coursers, and the Egyptian "ziczac" that now and then picks the crocodile's teeth, and is almost the same as the historic lapwing, so familiar in Scotland.

## CHAPTER XXV

### FROM GULLS TO KINGFISHERS

OUR scientific arrangement introduces next the gull family, followed by a series of groups that seems to the layman most miscellaneous. The gulls are a world-wide family of sea birds, seen also near bodies of water in the interior of continents, especially northward, which live on fish and floating edibles. They are mostly glistening white, often marked with black about the head and wings, except the big brownish skuas that live by robbing other gulls of their catch and their nests of young. A very distinct group in the family are the smaller terns, whose slender forms, long wings, and graceful flight give them the suitable name of "sea swallows." Another distinct lot is that of the low-flying black "skimmers." All these birds normally breed on sandbanks near shore, laying four handsomely variegated eggs in a mere shallow of earth, but a good many nest in colonies on the margin of freshwater lakes. The gulls serve well as scavengers, but are not good to eat.

Related to the gulls, but very different in appearance, are the small, dark-colored, quaint auks, guillemots and puffins of northern coasts, that look like miniature penguins, for they stand erect on two big feet. They are fishers, with great skill in swimming and diving, and breed in companies of thousands, sometimes, on the ledges of the sea-fronting

cliffs of Labrador, northern Scotland, Alaska, and Arctic islands. The extinct "great auk" of the North Atlantic coasts was a giant of this race.

Passing the sand grouse of Africa and Russia, we come to the pigeons, represented in a bewildering variety of forms in every part of the world. The United States has several species—the common wood dove, or mourning dove, the extinct "wild pigeon," once here in millions, the banded pigeon of the Pacific Coast, and several kinds of ground doves in the southwest. The rock dove, which is the original of the domestic varieties, is still wild in Europe, together with several other species; and the Orient abounds in representatives of the family, some of them large and extremely handsome, especially in the division called fruit pigeons. To this family belonged that famous bird of the past, the "dodo" of Mauritius.

There follow two big groups, the cuckoos and plantain eaters, and the parrots, which together have the peculiarity of two toes in front and two behind, instead of the customary three toes in front and one, or perhaps none, behind; the woodpeckers have the same "yoke-toed" arrangement, but are distinct otherwise. The cuckoos are mainly Oriental and very varied, although all show the slender form, long tail, and long curved beak that we see in our two American species, the black-billed and yellow-billed; the most aberrant one in our country is the queer, lizard-catching road runner of southern California. None of the cuckoos seems a good nest maker. The nests of our common ones are loose platforms of twigs, and both species often drop eggs in each other's cradles; but they, in common with almost all the other cuckoos of the world, do at least

incubate their eggs and care for the nestlings, instead of leaving that task to some foster parent, as does the similar cuckoo of Europe. The most extraordinary feature of this parasitic habit is the fact that the cuckoo often, if not always, first lays its egg in any convenient place, and then, taking it in its beak, carries it to another bird's nest and puts the egg into it. This accounts for the frequent finding of a cuckoo's egg in nests into which so large a bird could not have crept.

To record the fact that about 500 different kinds of parrots are catalogued will be a sufficient explanation of their dismissal with a few general remarks. The larger number and most striking examples—the great cockatoos for instance—belong to Australia and the Malayan islands, but the Indian region, Africa, and tropical America abound in parrots. Probably the northernmost of the whole family is our Carolina parrakeet, which formerly ranged in summer even to the Great Lakes, but now is almost exterminated even from the great swamps of the Gulf Coast. Of the two kinds most often seen in cages—a custom that is almost prehistoric in antiquity—the gray parrot is African, and the green or green and yellow “Amazons” come from South America.

Parrots are gregarious, nest in holes in trees, although a few live in holes in the ground or among loose rocks, and feed on all sorts of vegetable productions, including some very hard fruits cracked in their powerful bills, as is the habit of the gorgeous macaws of Central and South America. The lorries of Australia are provided with tongues brushlike at the tip, and besides eating seeds they lick the honey out of the blossoms of the eucalyptus

and other flowering trees, and in so doing effect the cross-fertilization of these trees in a country which has no bees to do that service.

Passing the brilliant rollers of the Old World, and the motmots and little gemlike todies of the New, we come to the extensive tribe of kingfishers, of which our blue and white example is a very modest specimen—but the only one we have, while 150 other species are counted in the rest of the world, most of them in the Austro-Malayan region and in Africa. They vary immensely in size, colors, food and habits. A large section are not “fishers” at all, but dwell in wooded places, and subsist on insects caught on the wing, and on reptiles, mice, etc., like birds of prey. Few groups are so diversified and entertaining as this one. Related to them are the bee-eaters, hoopoes, hornbills and others that bring us to the owls, a suborder of which contains the great nightjar family to which our whippoorwills and nighthawks belong, with the swifts and humming birds as near relations. Then come the woodpeckers, much alike all over the world (but absent from Australia), followed by the gorgeous trogons of Mexico and some other tropical beauties.

## CHAPTER XXVI

### PASSERINE BIRDS

WE have now run through the list of all the orders of birds except the last and largest—the “passerine” birds, the ordinary songsters of the fields and woodlands of the northern hemisphere. There are fifty families contained in the order. Here, among our North American migratory birds are to be found the kingbirds, pewees and other “tyrant” flycatchers; the larks of our western plains and eastern seashore; that sprite of the Rocky Mountain brooks, the ouzel; the waxwings, the butcher birds; the pretty greenish vireos that build those exquisite, cup-shaped hanging nests made of grapevine bark and spider’s silk; and the swallows that become so friendly every summer about barns, paying rent by diligent service in insect killing. Then there is that interesting little group of small and cheerful climbers, the nuthatches, chickadees, and creepers, that rid trees of hosts of injurious insects which they dig out of crevices of the bark as they scramble up and down the trunks, some of them continuing the good work all through the winter. These have their counterparts in Europe, for in respect of our common song birds, as of the birds of prey and game birds, the avifauna of Europe and North America is virtually one. The differences are mainly in the few representatives of tropical groups that visit northern countries in summer, those of Europe partaking

of the African or Indian families, while we have wandering species from groups that are properly inhabitants of Mexico and southward. Such, in fact, are our few humming birds, hundreds of species of which belong to the American tropics (and none to the Old World), our two tanagers, members of a **very large tropical family**, and our blackbirds and orioles, far more numerous in species south of the United States.

While we have many delightful vocalists, the best singers of all our birds are no doubt the thrushes, and that is true of thrushes elsewhere, for the European blackbird and mavis, the celebrated nightingale, the solitaire—both that of the West Indies and that of our northern Pacific Coast—and several noted musicians in the Orient, are of this melodious family. Which is the best singer of them all will never be settled, for the citizen of each country likes best that to which he is most used; but to Americans nothing can be better than the evening carol of the wood thrush, the serene hymnlike music of the hermit, or the sweet and wavering call of the veery. Yet in the South, where these northern thrushes are rarely heard at their best, the palm is given to the mocking bird, which, like the northern brown thrasher, rivals all in turn by simulating their notes in a liquid melody that, especially when heard in the calm of a moonlit summer evening, seems of surpassing beauty.

## CHAPTER XXVII

### THE BEASTS OF THE FIELD— SOME PRIMITIVE TYPES

WE have now arrived at the highest rank in the scale of animal life—the four-footed, hair-clad, milk-nursed denizens of our woods and fields—the subclass *Mammalia*, mammals.

These are the “animals” of popular speech, but accuracy requires a more distinctive expression, for every living thing not a plant is an “animal.” Unfortunately no such distinctive term exists in our language, and hence we must borrow from the Latin the word “mammal” for this group. It is correct, easy to remember, and there is no reason why it should not be used popularly as well as scientifically. It is good, because it is exact, and expresses the one great distinction which separates mammals from all other animals—the feeding of the young on milk secreted by the mother. The milk-producing glands were called in Latin “*mammæ*,” whence our word “mammal” and the technical term *Mammalia*—animals that suckle their young.

Another peculiarity of the group is the coat of hair—persistently growing threads of horny substance produced from the skin in greater or less abundance and of varying quality and color. Its chief purpose appears to be that of keeping the body warm; and, as in the case of the feathers clothing birds, it enables the blood to rise to and maintain a

temperature much higher than that of the air; hence the mammals are "warm-blooded." This condition, gradually acquired, stimulated their activity and hence their brain development, the result of which is a higher degree of intelligence than is manifested, as a class, by any other animals, and a moving cause of their progress to the highest plane of organic evolution.

The history of the evolution of the Mammalia may be traced back to obscure beginnings in the Triassic, the oldest of the three divisions of the Secondary or Mesozoic era. Just preceding that time there flourished a group of reptiles, the Theromorpha, whose skull, teeth, and forelimbs were very like those of a modern beast of prey; and zoölogists consider it "altogether probable" that the origin of the mammalian branch must be looked for among their number. It is not doubted, however, that true mammals, although very small and inconspicuous, existed throughout the whole Mesozoic era, despite the fact that the world at that time was filled with ravenous reptiles. Indeed, it is believed that their steady development was an important agency in destroying the reptile population, largely by eating their eggs. At any rate, before the end of the Mesozoic era the two grand divisions of Mammalia, Prototheria and Eutheria, had become established; and also the two primary divisions of the latter, the Marsupials and the Placentals, had been separated. Then came that extraordinary change in the physiography of the globe that marked the end of Mesozoic conditions and introduced those of the succeeding era named Tertiary. In the broader and higher land areas and the drier and more invigorating climate that followed, producing a vegetation tending constantly to

become like that of the present, mammals found increasingly favorable conditions, and became the dominant race of animals.

#### RELICS OF PRIMITIVE TYPES

There live in Australia and New Guinea two curious little animals that most nearly represent in their low and generalized organization the primitive mammals, and differ so essentially from all other mammals that they are classed by themselves as Prototheria ("first beasts"). They are the duck-bill (*Ornithorhynchus*) and the spiny anteater (*Echidna*). The duckbill is a small, softly furred, web-footed creature, as aquatic in its habits as a beaver, which finds its food in the worms and other things that live in and on the mud of its chosen stream, and digs a burrow in the bank for its home, where it stays most of the daylight hours, and where its young are born. Its special peculiarity is that instead of the muzzle and mouth of an ordinary mammal, it is furnished with a bill like that of a duck, and each jaw is armed with horny plates to do the work of teeth; in the young ones true molar "milk" teeth are present, but are soon shed. The cheeks contain pouches in which a quantity of food can be stored, the animal carrying it in to the safety of its burrow to be eaten, and so avoiding the danger of being out for a long time of feeding.

The echidnas are equally small, about eighteen inches long, covered with a mingled coat of hair and strong spines, and mounted on short legs and feet armed with powerful claws, for this animal dwells on land, and not only burrows, but must tear to pieces the hills of the ants that form its only food. Its round little head terminates in a long,



OPOSSUM MOTHER AND YOUNG

Photo, American Museum of Natural History



ANTEATER, WHICH LIVES ON INSECTS CAUGHT  
IN THE STICKY SALIVA OF ITS LONG TONGUE



SLOTH, WHICH KEEPS TO TREES AND  
IS ALMOST HELPLESS ON THE GROUND

slender snout containing a ribbon-shaped tongue with which it licks up the ants from their ruined nests.

The striking peculiarity of both these queer creatures, however, is the fact that they lay eggs. These are few—sometimes only one—and recall those of reptiles in their relatively large size, parchmentlike shells, and abundance of food-yolk. The duckbill deposits her eggs in her grass-lined burrow nest and covers them with her body until they quickly hatch. The blind and naked young then apply their lips to the nearest part of the mother's abdomen, and suck milk through the pores of the skin. In the echidna one sees a little advance on this extremely simple beginning of nursing; for here, instead of being laid in a burrow nest, and covered by the mother, the echidna's egg is placed by the mother within two parallel folds of skin which at that season form a deep groove in the abdomen inclosing the nursing area, and is held there until it hatches. When the young has attained a certain size the mother removes it from the "pouch," but takes it in from time to time to suckle it.

Such are the Prototheria—one of the grand divisions of Mammalia, set apart by reason of their laying the eggs from which the young will afterward be born, whereas in the other division or Eutheria ("proper mammals") the "embryos," or unborn young, escape from the eggs in a less or greater degree of development before their birth from the mother. This period between the conception of life in the egg and its emergence at birth is called the period of gestation, and is much longer in large animals than in small ones. Fundamental differences in method of birth divide the

Eutheria into two groups, designated as Non-placentals and Placentals.

### THE MARSUPIALS

The word marsupial means "pouched," and refers to the most characteristic peculiarity of the non-placental division (order Marsupialia), which is the possession of a more or less pocketlike fold in the skin of the abdomen of the females within which the extremely immature young are nourished.

The egg-laying mammals, also nonplacental, have the young inclosed in a protective shell that they keep warm, as do the birds, until the embryo is sufficiently matured to be safely born. In the marsupials nature meets the difficulty in another way. The embryo is but little advanced when born, in fact it is utterly helpless and minute, being, even in the case of the largest kangaroos, hardly as big as a mouse. It would be fatal, of course, to turn it loose upon the world; and therefore the mother is provided with the pouch already described.

The instant an embryo is born the mother picks it up and places it within the pouch, where it crawls about until it touches and instinctively takes hold of one of the threadlike teats. As it gets stronger it leaves the pouch now and then, but returns to it for nursing, sleeping, and protection when alarmed, until finally it departs altogether.

This description applies to the most advanced families of the order. In the oldest and most generalized families of marsupials, such as the banded anteaters, there is virtually no pouch at all.

As almost the whole marsupial tribe are natives of Australasia, it is odd that the family with which we must begin a list of them—the true opossums—

should be American, and quite unknown in Australia. This is explainable when it is known that this family (*Didelphidæ*) is the most archaic of this ancient tribe, and was well established in Cretaceous times, and then and later was widely distributed in Europe and on this continent; yet so little change has occurred in the race that teeth from the Laramie formations of Wyoming are hardly distinguishable from those in the jaws of our 'possum-up-a-gum-tree to-day. No wonder the quaint creature is hoary and wrinkled; he is a very Methuselah among mammals, and looks it! All opossums seem to have disappeared from Europe before the close of the Miocene, but continued to survive numerously in South America. They probably owe their long career, in competition with animals of so much higher grade, to their small size, forest life, nocturnal habits, ability to eat all sorts of food, and, most of all, to their great fecundity. Our common opossum is the most northern of its kind, and ranges over the whole country as far north as the latitude of Lake Erie; it appears never to have crossed the Hudson River until comparatively recent times, but is now frequently met with in New England and on Long Island. It is at home in all sorts of places, except, perhaps, on the dry plains, for it is primarily an arboreal animal, aided in climbing about trees by its naked, prehensile tail, by which it may hang to a branch while using its forefeet to rob a bird's nest or gather fruit. It will eat anything it can get hold of, and with its sharp teeth, which number fifty, will kill animals as large as itself; hence it is a destructive raider of henroosts and sitting birds as well as a seeker of mouse nests and insects.

Opossums are amazingly prolific, and have broods of a dozen or more in many cases. These often crawl on the mother's back, and cling with claws and twisted tails to her fur and tail, and so are carried about. Burdened by these kittens she hunts daily—or rather at night, for the most part—and defends them savagely and bravely against foxes and other enemies, often successfully standing off the farmer's dogs. With a family to defend, or when faced by any foe that is at all equal to its powers, the opossum does not resort to "playing 'possum," for this is a last resource when surprised and "cornered" by an overwhelming danger that it can neither avoid nor cope with.

The proverbial feigning of death by this animal (many other small animals do the same) has excited much popular interest, and has received many explanations. I have suggested that it is a survival of a practice which in past ages had been an advantageous ruse of the ancestors of the opossums.

Several other species of opossums exist in Central and South America, some much smaller than ours and one hardly bigger than a mouse. One kind, the "yapock," is aquatic, dwelling on land only during the infancy of its progeny, and until they are old enough to be taught to swim. All the marsupials inhabiting the Americas (except a rare little mole-like one in Patagonia), belong in the family Didelphidæ; but this family is not known in Australia, where the so-called "opossums" belong to a different tribe. They were named after our common northern opossum, which was known to science before Australia and its pouched fauna were discovered.

One of the extraordinary things in zoölogy is that Australia, and the near-by islands that constitute

with it a faunistic province, has no indigenous mammals (except a few mice and bats) other than marsupials, which have become so diversified as to represent the varied kinds of animals seen elsewhere; and no marsupials live anywhere else in the world except our single and primitive American family. This curious situation has caused much discussion. It is known that in late Mesozoic times marsupials were scattered all over the globe, but became exterminated everywhere outside of Australasia and America long before the present era. The Australian marsupials are supposed to be the survivors, flourishing in a favorable region; but why no other mammals survived there is still a puzzle. Another theory is that Australia, regarded as formerly a part of a much larger southern continent, is the original center from which the ancestors of the Marsupialia spread, but failed to maintain their race outside of their original home, with which South America was then connected.

The most archaic of these marsupials is the celebrated Tasmanian "wolf," or thylacine, which resembles in size and shape a pointer dog, but with a longer muzzle, and that long tail which seems to be a general characteristic of the Marsupialia. It is brownish gray, with a row of darker bands crossing the hinder half of the back, and is one of the most swift-footed and savage hunters in the world. It is confined to Tasmania, where it became so destructive to sheep when the island was settled that it was killed off until almost exterminated. This island was the home, also, of another smaller beast, looking somewhat like a wolverine with the head of a hyena, which was so morose, savage, and untamable that the settlers named it "Tasmanian

devil," and destroyed it as rapidly as they could. It hid by day in some rock den and made its forays at night. This truly diabolic creature belonged to the family of dasyures, which is represented in Australia by several small, predatory beasts called "native cats." They fill the rôle there of our northern martens and weasels, and most of their time is passed in trees, although some are fond of hunting amid rocks and brush. They like to come about ranches and villages, where they are the pest of poultry keepers, but are rarely domesticated, even partly. Another carnivorous group (phascogales) contains the "pouched mice," which are not mouse-like, except in size, but have more the nature of shrews that live in trees and hunt birds and any small creatures they can catch.

Of the phalangers a curious specimen is the wombat, named "native bear" by the early colonists—an animal about the size of our woodchuck, shaped like a miniature bear, and living mainly on roots, which it digs at night with its powerful claws; its thick fur makes its skin valuable in market. Related to it structurally, but much like our gray squirrel in shape, and having an even longer and more bushy tail, is the charming sugar squirrel, which dwells in trees, and sails in long flights from tree to tree in the twilights and on moonlight nights just as do our flying squirrels; there are also tree phalangers so small they are called "flying mice." Other tree-living phalangers are the "opossums" of Australia, whose soft gray pelts are exported in great numbers to foreign fur markets.

The kangaroos and wallabies (Macropodidæ) represent the highest development of the marsupial type, and number some fifty species spread over all

Australia and New Guinea. While the majority inhabit open grassy plains, others brushy districts and rocks, and a few dwell in trees, the kangaroos proper include half a dozen of the largest kinds, the commonest of which is the great gray "boomer" or "forester," of the colonists, often seen in menageries.



A KANGAROO MOTHER

Showing young carried in the abdominal pouch

It stands four to five feet tall, with a tail thirty to thirty-six inches long; but this size is considerably exceeded by that of the red or woolly kangaroo, of eastern and southern Australia. Furthermore, fossil remains show that in the Pleistocene era kangaroos far bigger than even these existed there in numerous extinct species—one, for instance, whose skull alone measured nearly a yard in length. These animals take the place in Australia of the deer of northern countries. They are very gregarious, and

are always to be met with in droves. Each drove frequents a certain district and has its particular camping and feeding grounds. The animal has a dreadful weapon of defense in the powerful hind claw, which it can use like the tusk of a boar.

The smaller kangaroos are called "wallabies," or brush kangaroos, and frequent scrub jungle and rocky places. These furnish most of the skins and leather sent to European markets and, like the big species of the plains, have been greatly reduced in numbers by hunters and sheep herders. Some of them are confined to the rough deserts and mountains, where they jump about the rocks with astonishing agility. One small genus includes the swift harelike species that resemble our jack rabbits in habits; and there are also the "dorca" kangaroos, which are arboreal in habit and handsomely colored. Another group are ratlike in form, colors, and manners, running rather than leaping, and dwelling among scrub and grass, scratching the ground all day in search of the roots upon which they feed, and making havoc in the frontiersman's potato patches. Several kinds have prehensile tails, which they use apparently only to carry to their underground homes the long grass of which they make their beds. They associate in connected burrows like a rabbit warren.

In the varied forms and functions they present, as beasts of prey, as grazers or root diggers, as ground-running, tree-climbing, burrowing or cave-haunting forms, some solitary and slow, others agile and gregarious, the marsupial tribe in its isolated corner of the earth exhibits an epitome of the whole mammalian world. It shows in a conspicuous way how the necessity and habit of making a living in varied circumstances, and exposed to lively com-

petition, restricting every species to a particular manner, brings about a suitable modification of structure.

#### THE EDENTATA—ANTEATERS, SLOTHS, AND ARMADILLOS

At the base of the great division of Eutherian mammals, to which belong all that remain to be described, is found the order Edentata ("toothless"), whose modern representatives are few and unimportant in comparison with those of past ages, when gigantic ground sloths, armored glyptodons, and other fossil species flourished in a luxuriant world. The name is not well chosen, for many of these animals possess at least a few teeth, but always composed of vasodentine and not coated with enamel. Although the origin of this race is obscure, it was certainly far in the past, for its characters are archaic in many particulars, and its members are often far separated in structure, and also in their geographical distribution. Two families belong to the Old World, one in the Orient and another in South Africa, but all the other edentates are American. The Oriental one includes most of the "pangolins," or scaly anteaters, which are covered from head to foot in a coat of mail formed of overlapping horny plates, and can roll themselves into a ball that will defy any jaws not big enough to tear them to pieces; while the African family consists of the naked, long-nosed aard-vark ("ant bear"), which burrows in the ground, and cuts its way at night into the mud forts of termites and other ants in search of its favorite food. These two ancient creatures differ so much in their anatomy from the American edentates that they are classified by some

naturalists in a separate order (Fodentia); and they differ almost as radically from one another.

It should not be surprising to find most of the modern edentates in South America, since that is the most ancient and unchanged of all the continents; but a few sorts of anteaters, sloths, and armadillos alone remain where once their race, in its heroic age, dominated the world of its time. The puny survivors look and act like the relics they are. The "great" anteater, or tamandua, standing eighteen inches or more in height, has flatfooted, bearlike hind feet, and short forelegs that end in huge claws bent under, or backward, so that the animal walks on the outer face of its toes. Its tail is a great bushy mass of hair with which the animal may cover itself as with a blanket, and its long neck tapers off into a head with a very long nose and little room for brains. The big claws are not used for burrowing an underground home, but for digging up the nests of ants and termites which it licks up with its long, sticky tongue. When one realizes the enormous colonies of ants in the tropics it is not amazing that so large an animal should subsist exclusively on these minute creatures. The claws are formidable weapons of defense also, the animal throwing itself on its back and defying the foe, or rising on its hind legs and giving a tearing, bearlike hug that even a man might well fear. This is a slow-moving creature, more fond of open country than forests; but a smaller tamandua belongs wholly to the woods and spends both days and nights in the tree tops, tearing open the burrows and nests of arboreal insects and devouring their inhabitants and their stores of honey and young. A third species is the rare little yellow two-

toed anteater of the Isthmus region, which appears to live almost wholly on wasp grubs.

Much like these in organization are the two species of sloth, hairy creatures that hang all day long by their long, muscular limbs and two or three curved claws, underneath a branch of the tree through whose top they slowly creep about at night, collecting, crushing with their peglike teeth, and swallowing the leaves that constitute their fare. Their long hair, naturally gray, becomes green by accumulating a coating of minute plants that thrive on it, and this helps to conceal the sloths amid the foliage, yet they are killed by eagles and by all sorts of beasts of prey, against which they have no means of defense. These listless creatures are the degenerate descendants of a very long ancestry. The early Tertiary rocks of Argentina contain the bones of small slothlike animals that apparently were ground dwellers and must have been active diggers. Later that region became filled with larger ground sloths, apparently their descendants, that are believed to have browsed on bushes and trees; and some of these became the megatheres of the late Tertiary, which were as big as elephants. Similar giants inhabited North America.

Even in the earliest days known to paleontologists the anteater-sloth group had become well separated from their fellow edentates, the armadillos, arguing a far-preceding origin. In the later Tertiary the latter type developed such huge and heavily armored forms as the glyptodon, on whose bony shell the teeth of even the great saber-toothed tigers of the time could make little impression. These grotesque tortoiselike glyptodons, of which there was a great variety, were vegetable eaters, and some

survived to a time so recent that there is evidence that they were finally killed off by human hunters. Beside them were smaller armadillos, more like the modern ones, which are armored with overlapping belts of horny material between which coarse hairs sprout ; but the amount of this armor varies greatly among the several species scattered from Patagonia to northern Mexico. In some it is a continuous shell, in others it consists of several belts, in still others is nearly absent. Armadillos are carnivorous, digging out worms, grubs and the underground nests of wasps, catching insects of all sorts, stealing eggs and young from ground-nesting birds, killing serpents by leaping on them and sawing their bodies in two by means of the rough edges of their plates. In some places on the pampas armadillo burrows are so numerous as to make riding dangerous.

## CHAPTER XXVIII

### THE GNAWERS

**T**HE great order Rodentia—rats, mice, rabbits, porcupines, squirrels, beavers, etc., derives its name from the Latin verb *rodere*, to gnaw, or eat away (something), and is characterized by the great development of the front (incisor) teeth, by means of which rodents get their living by biting off, or gnawing through, the plants and woody stems on which they feed, or which they use in constructing their dwellings. All are primarily vegetable eaters, yet none will refuse a meal of flesh when opportunity offers to get it, and some are decidedly carnivorous, especially as to fish. They are distributed all over the world, including the Australian region. They are chiefly terrestrial, and often burrow or live in ready-made burrows. Some are aquatic, such as the voles; others, like the squirrels, are arboreal. In perhaps a majority of the forms the hind legs are much longer and stronger than the forelegs, giving the animals great leaping power, while the forefeet, with their long and flexible fingers, are constantly used as hands. Many are beautifully marked in varied tints of gray, brown, red, and black, so that their pelts have value in the fur market; and their flesh is an important element in human food. On the other hand the activity of these animals, when numerous, causes serious damage to gardens, crops and orchards and one of them, the rat, is

unquestionably the most dangerous animal to human health and prosperity in the whole animal kingdom. The fecundity of the smaller, murine species, is great, and from time to time they increase inordinately in favorable places, and swarm abroad in vast and destructive migrations. Were it not for the fact that the rodents furnish the principal part of the food of predatory mammals, reptiles, and birds, and are thus kept down, the globe would soon become so populous with this tribe that hardly anything else could maintain existence.

The distinguishing anatomical characteristic of the rodents is the dentition. The canines, so essential to carnivorous, predatory animals, are here completely absent, and a long empty space intervenes between the incisors and the molars, or cheek teeth, which vary greatly in number and form among the different families. The incisors consist of a single pair in each jaw, very large and strong, and composed of vasodentine, *faced only* with hard enamel, often yellow or red. As the softer substance behind the facing wears away more easily, the incisor takes a chisel shape, leaving the hard enamel in front projecting slightly as a cutting edge; thus these teeth always remain sharp. The rodents are traced back in their lineage to the order Tillodontia of Eocene time. The oldest family of modern type in the order is that of the squirrels.

Let us begin with the rabbits and hares (family Leporidæ). The name properly applies to the Old World species *Lepus cuniculus*, the burrowing wild rabbit from which all our various domestic rabbits are descended, whose special characteristic is the fact that they live in holes in the ground of their own digging, and in large colonies called warrens. All

the other species make their breeding beds and resting places on the surface of the ground, in the best concealment (outside of forests) that they can find. Such a home is called the animal's "form," and when it contains a litter of young the mother covers them with a blanket of hair which at that season she is shedding copiously. Strictly speaking, all the Leporidae, except the *cuniculus*, are "hares"; but the general term "rabbit" is now so common that the scientific distinction is of no consequence. Europe and Asia have two kinds of hares, and several exist in this country, such as the familiar "cottontail" or bush rabbit of the east, the southern swamp rabbit, and several species of large, long-eared, swift-footed hares of the western plains called "jack rabbits." The most important one, however, is the large northern one named "snowshoe rabbit," because in winter it receives a broad growth of hair on the feet, aiding it in traveling over the snow. This rabbit turns white in winter, the hairs losing their color with the advent of cold, as also does the big arctic hare which wanders as far north as land extends. These northern hares are the chief dependence for food in winter of all the Canadian fur-bearing animals, and indirectly of the native Indians. Consequently when, as happens at intervals of a few years, the rabbits of a district all but wholly die off by an epidemic, a famine and dreadful distress occurs—or used to when civilized aid was less available than now—in northern Canada, and the commercial outcome of furs is greatly diminished.

As the hares feed on herbage and bark, obtainable all the year round, they are abroad in winter; but they have a family of small cousins, the pikas (*Lagomyidæ*) that inhabit our western mountain

tops above timber line and must hibernate. Other species abound in the Himalayas. They are little, short-eared, tailless creatures that make their homes in companies among loose rocks, and store in their deep crevices enough dried grass and flowering plants to keep themselves alive until the late spring of those cold heights. Western folks call them conies.

The porcupines are large, plantigrade rodents notable for the mixture of quill-like spines with the hair. This is most conspicuous in the European species, which bristles with spines reaching far beyond the hips and concealing the tail, forming an excellent defensive armor. Some smaller African and East Indian species are less well armed, and have longer tails, at the end of which are tufts of spines, making an effective weapon. All of these pass their time and get their food on the ground. Our American porcupines (family *Cercolabidæ*) differ somewhat anatomically and live for the most part in trees, although our common eastern porcupine wanders about a great deal in summer, especially at night, feeding on herbage, and rejoicing in a find of bones or other saline food here and there. It is defended by a coat of long black hair in which spines are plentifully mingled, and the short, flat tail, covered with thick spines, may give a sidewise stroke that makes man or beast cautious about attacking an animal that otherwise seems so lethargic and helpless. The porcupines of this family, however, really belong to trees, where they slowly consume the foliage and tender bark, and remain quietly through even Canadian winters. The Pacific side of the country has a similar species in the yellow-haired porcupine; and several smaller kinds exist in

Central and South America with scanty spines and long prehensile tails.

Closely allied to the porcupines are the gregarious viscachas of the South American plains, that live in "villages" of burrows, and much resemble prairie dogs in appearance and habits; also the chinchillas of the high levels of the Andes, whose soft gray coat is one of the prizes of the furrier. Here, too, come the swift-footed, slender agoutis and pacas of South America, many species of which exist and are useful as food; and a neighboring family contains the little cavies, from one of which are derived our pet "guinea pigs," which are not pigs and do not come from Guinea; also their cousin, the almost aquatic capybara, which measures three feet long, and so is the biggest known rodent. This is much hunted for its flesh, and is the principal prey of the jaguar.

This brings us to the world-wide tribe of rats and mice formed by a group of eight families, of which the typical one (*Muridæ*) alone contains a third of all *Rodentia*, and the other seven creatures differing greatly from these familiar models. Many are small, such as the house mouse (originally a native of southeastern Asia, as also were the rats that commerce has carried all over the civilized globe), and the even tinier harvest mice, gray or brown in plain color, and with long, slender and nearly hairless tails and legs fairly equal in size. Thence in size they grade up to the stature of the rat, and from that on to the South African "springhaas" which is as big as a rabbit, and to our muskrat, two feet long, counting in its tail. Although essentially alike in structure some have varied widely from the ordinary type. Thus the jerboas, several species of which inhabit the plains of Asia and Africa, have the hind

legs so long that their bones are considerably longer than the distance from the root of the tail to the nose; and they progress in long rapid leaps, balancing themselves by long tails, often tufted at the end. The big "jumping hare" of South Africa has much the appearance of a kangaroo with a squirrellike tail; and a genus of exquisitely dressed mice in our sandy Southwest are called "kangaroo" mice. In fact one of our commonest reddish field mice, found all over the country, has similar proportions, and is remarkable for its long leaps when hurried.

A shortening of the tail is seen in the voles, to which the common meadow mice of various species belong, and still more in the lemmings, in the Old World mole rats, and in our pouched gophers. All these are not only ground-keeping kinds, but burrowers, and have no use for a long tail, save in the case of the muskrat, which is really a big vole that has taken to an aquatic life, and needs an oar to scull himself through the water; for muskrats swim more by means of their tails than by their feet. The foremost burrowers are the pouched gophers, whose long tunnels, and food-getting, do so much damage to crops in the central plains region of this country. They must be distinguished from the ground squirrels, also called "gophers."

An interesting diversity of habits may be met with here. Some rodents live in deeply excavated burrows, others in shallow diggings or holes in stumps and rock crevices; some, like the water voles, reside in holes in the banks of streams, or, like the muskrat, heap up "houses" in a marsh in which to pass the winter in security; while still others construct ball-like nests among the herbage, or in bushes and trees. Some truly hibernate in cold countries,

like the famous dormice of Europe, and our equally sound sleeper, the American jumping mouse; but mostly they stay in snug habitations and live through the winter on collections of food, or, like field mice, gather seeds abroad even in the coldest weather, or poke about under the snow for food, as do the lemmings. From time to time certain species, especially of the short-tailed field mice and the lemmings, multiply excessively in some district, and then are forced to spread away from their birthplace in those migrations of myriads which form the "plagues" that devastate large tracts of country. They march on until an accumulation of enemies and an epidemic of illness combine to kill them off.

#### SQUIRRELS, WOODCHUCKS AND BEAVERS

Squirrels in form and activities are much alike all over the world, and are absent only from Australia and Madagascar. The long, bushy tail that makes so excellent a blanket as it is wrapped about their bodies when curled up asleep, is the badge and pride of the tribe. They inhabit hollows in the trees or sometimes holes among their roots, and in summer make globular nests of leaves and twigs in which the young are nursed and trained. Nuts form their staple food, but berries, fruits, roots, funguses, insect grubs, etc., offer changes in fare with the recurring seasons. Sometimes great ingenuity is displayed in getting at this food. Some species are arrant robbers of birds' nests, and now and then kill and eat small birds and mammals; and the older males are resolutely kept away from their babies by the mothers for fear of cannibalism. This catholic appetite, and their willingness to wander from place to place in search of things seasonable, enable squir-

rels to find food of some sort every month of the year, yet most species have the forethought to lay up in more or less secret places a winter supply of provender; consequently no species of *Sciurus hibernates*, strictly speaking.

This storing of winter provender is a matter that has been regarded with more general interest, perhaps, than any other feature of animal economy, and is mainly manifested among the rodents, although practiced in a limited way by some others, as for instance, by weasels and foxes. It looks like conscious foresight of the famine time to come, but it is no doubt in the main, if not wholly, instinctive, since the young, who have had no experience of the winter's scarcity or imprisonment ahead, make suitable preparations. It seems to me that this habit, so necessary to the existence of small, vegetarian creatures in cold climates, arose in some such way as this:

The little animals that store supplies designed to keep them alive through the winter are those whose food is for one reason or another unobtainable then. Remember, also, that they are feebly endowed with powers either for defense or for escape outside their homes, and when gathering their food must not loiter much to eat as they go, but must pick up what they can carry and hasten to the safety of their doorways. This is the reason why surviving species of such animals have acquired cheek pouches, in which they can transport a fair meal of their food to be eaten at home at leisure.

During the larger part of the year food is scant, and these rodents get into the way of picking up every bit they can find, and seem so restless and energetic that some of them, such as the viscachas and pack rats, accumulate about their burrows or

nests quantities of inedible things, moved, apparently, by mere objectless acquisitiveness. The search for food, the foremost occupation and anxiety of these small wood-folk, would be increasingly stimulated as the ripening season of the seeds and nuts on which they depend advanced, and the impulse to incessant industry, so necessary in the poorer parts of the year, would now be overworked, and each animal, in his haste to be up and doing, would constantly bring home more food than would be consumed, so that it would pile up in the accustomed "dining room." The gradual failure of outdoor supplies, as winter came on, would lead to the eating, with increasing frequency, of those fragments casually saved in and about the burrow or house, which, from their nature, would not have decayed. The animal which had been most busy and clever in food gathering would own the largest amount of the leavings of these autumnal feasts. Having the most food he would be among those of the colony or neighborhood strongest and most likely to survive, and to give to his offspring the tendency to strength and industry which had been his salvation. This would be continued and shaped by the process of natural selection into a valuable, instinctive habit of gathering nonperishable food in large quantities every autumn, and thus providing themselves with stores to last through the coming winter; but it does not follow that the squirrels and mice are conscious of this wise forethought.

The striped, chattering, ever-busy chipmunks, of which America possesses several delightful species, although able to ascend into trees, and frequently doing so, are groundlings, and fond of rocky places into whose crevices they can quickly rush when an

enemy is seen or heard; hence their fondness for the stone walls that in the East divide farm fields, and in general they are more inclined to associate with man and his works than are the tree squirrels, although the grays lend themselves readily to the semidomestication of residence in village streets and city parks, as the red never does. The chipmunks dig long underground tunnels, enlarged here and there into chambers serving as bedrooms, store-rooms for food, and refuse bins; and the northwestern species are so numerous that between what they eat and waste in gardens and grainfields and the bad runways for water their galleries make, they are justly regarded as a pest.

These pretty but troublesome chipmunks are called "gophers" in some parts of the West, but that name is more generally given to the gray or brownish ground squirrels of the plains, classified as *spermophiles* by naturalists; and they are so varied, numerous and destructive wherever grain is grown, from the prairies of Kansas and Nebraska to the California valleys, and northward to the Saskatchewan, that extensive and costly poisoning operations are necessary to suppress them. Similar to them, but larger, are the prairie dogs, whose communities, or towns, of burrows and tunnels render useless large tracts of land in the southern half of the plains. Very similar animals to these abound in Russia and eastward throughout the open country of central Asia. They have undoubtedly increased much within late years through the killing off of the natural enemies that in the old days held their multiplication in check.

The prairie dogs used to be called "marmots," a term that applies more properly to some larger Eu-

ropean burrowing rodents and to our woodchucks, which are so common all over the eastern half of the country, and, in another species, on the summits of the northern Rockies, where they are known as "whistlers." The most remarkable thing about them is the length and intensity of their dormancy in hibernation. There remains only the beaver, the largest of the rodents except the capybara, and altogether the most important one, measured by the value of its fur, and by the service its race has done through thousands of years in preparing, by its clearings and dams, valleys for man's cultivation.

Every beaver settlement is a true colony, the offspring of some previous settlement, which may be hundreds of years old. When such a settlement becomes too populous for the food supply, young males and their mates travel to some fresh spot by a small woodland stream, and begin life by digging a burrow in the bank with an underwater entrance, and at once dam up the stream by piling sticks, sod and mud across its current at some favorable spot below their home, the effect, if not the conscious purpose, of which is to maintain a depth of water in the stream at all seasons sufficient to cover the entrance to the burrow, and also to permit the storage of green wood under water (and ice) near the home for food (they eat the bark) during the next winter. The young beavers born that season will remain through the winter with the parents, and a domelike house is usually built in which the family lives. Next season the young set up a home for themselves near by, and so the colony grows. Beavers get most of their food by cutting down trees other than evergreens, and gnawing the bark. As the trees disappear near the bank, and the colony increases, the

dam is enlarged so as to spread the set-back water over a wider territory; and later canals are cut deep into the woods, permitting far-away trees to be felled, and their pieces floated to the houses, especially in gathering the supply for winter. Old dams are sometimes 100 or more yards long, and are built with astonishing intelligence with reference to holding back a great breadth of water. These are diligently and skillfully repaired; and the houses become, in the course of years, big enough to accommodate three generations of beavers at once, and are so massive, especially when frozen in winter, which is the time of most danger from their enemies, that they are practically safe from attack. From such a mature colony others are continually formed, until in a level, swampy region the whole district is well occupied by beavers. This is possible now, of course, only in the remote Northwest; but a few beavers survive in the Rocky Mountain region of the United States, under protective laws, and they are still numerous in the more thinly settled parts of Canada, and furnish a large return to trappers.

## CHAPTER XXIX

### MAMMALS OF THE SEA

**W**HALE is a general name for the extensive and varied order of marine mammals termed in science Cetacea. Their origin is obscure, but it is certain that their very ancient ancestors were land animals, evidence of which is afforded by their anatomy, especially in embryonic and very young specimens. Here are classified not only the great true whales but their smaller relatives, the sportive dolphins and porpoises, the grampuses or blackfish, the white whales often seen in the lower St. Lawrence River, the killers, and such out-of-the-way forms as the narwhal, from whose snout projects a long twisted "tusk," which is a strangely overgrown incisor tooth. In all these animals the shape is fishlike, as is required by the fishlike habits; the skin is smooth and usually blackish, or black with white markings; the forelimbs have become paddles and the tail a pair of horizontal flukes. As they are mammals with lungs and breathe air, whales must come to the surface frequently for that purpose. At the instant they emerge the pent-up air is expelled from the lungs through the nostrils at the top of the nose. In the case of the larger species this big discharge of moist breath condenses in the cold air into a visible vapor, often mixed with sea spray, which is called a "blowing"; but no water is expelled from the mouth, with which the "blowholes" have no

connection. The smaller kinds of cetaceans, of which the variety is immense, are in the main fish-eaters, but the killer seizes and devours porpoises and seals also, and a band of them may unite to worry a big cachalot to death. Most species go about in small bands, or "schools."

The great whales are of two distinct families: (1) baleen whales, and (2) toothed whales. The first take their name from the blade-shaped plates of horny material (whalebone) hanging, to the number of two or three hundred, from the roof of the mouth, each central blade eight or ten feet long in ordinary cases. These "right" (i. e., proper) whales, as they are called by the men who hunt for and harpoon them, are huge creatures often fifty to seventy-five feet long, ranging all northern oceans, even amid arctic ice; yet, despite their bulk, they feed exclusively on the small crustaceans and other minute creatures of the plankton swept into the mouth by the million as the whale rushes along the surface, the water scooped up escaping from the sides of the mouth, and the food being caught by the fringes of baleen and swallowed like a continuous meal. In addition to the whalebone obtained from these whales the hunters cut away and save the thick layer of fat (blubber) under the skin for the sake of the oil it yields. The beeflike flesh of the muscles is good meat. This kind of whale is becoming very scarce.

The toothed whales consist of the single species called sperm whale, or "cachalot," which is of gigantic size, a lesser cousin ("kogia"), and an inferior genus, the beaked whales of the Antarctic. All are more common in the tropics and South Pacific than elsewhere. The great sperm whale differs in form from a "right" one mainly in having a huge, flat-

topped, almost square-fronted head, beneath which is hinged a somewhat shorter underjaw. The cavernous mouth is armed with strong, pointed teeth, and these whales prey on fish and especially on cuttlefish. They can swallow whole nothing larger than a salmon, but can bite larger prey into manageable pieces, and have more than once seized and crushed a boat in their jaws. The cachalot attacks the giant squid whenever it meets one and the marks of the squid's winding arms and cruel suckers are often seen on the hides of whales as scars of some struggle between these Titans of the deep. The value to mankind of the sperm whale lies in the liquid fat and the valuable substance, spermaceti, that fill a vast cavity in the top of its skull, a single whale yielding several barrels of it, from which the commercial "spermaceti" and a fine oil are extracted. In their intestines are frequently found lumps of the secretion known as "ambergris," used as a base for perfumes, the price of which is so high in the market that a few pounds will cover the expenses of a ship's voyage. Ambergris is also found floating in the open sea or cast up on shore, and for a long time its origin was unknown.

## CHAPTER XXX

### THE WORLD'S HERDS AND FLOCKS

THE great tribe of animals called Ungulata ("hoofed") or Herbivora (eaters of herbage—herbivores), combines two types of structure into which they have diverged since their origin at the dawn of the Tertiary era, namely:

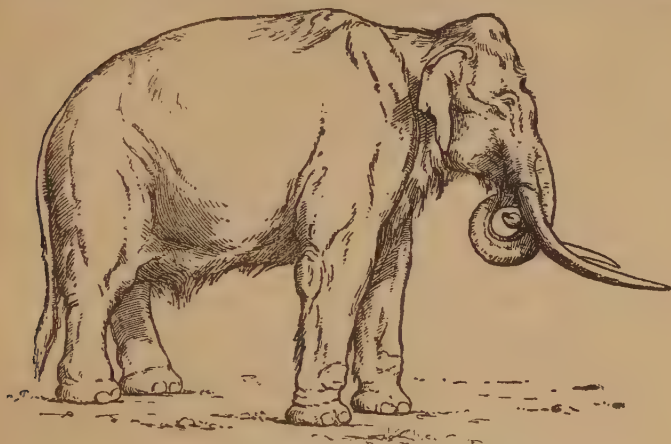
I. Odd-toed, or solid-hoofed, ungulates (Perissodactyla), typified by horses; and

II. Even-toed, or split-hoofed, ungulates (Artiodactyla), typified by the cattle.

They exist in every part of the habitable globe except Australasia, have furnished sustenance to the larger Carnivora, and have supplied the need of man for assistance in his labor, and with materials for food, shelter, and clothing. Without them modern civilization would have been impossible.

Both divisions have lost the plantigrade (flat-soled) walk of their early ancestors, and now step on the tips of their toes. This has been gradually gained as an adaptation to the increase of dry land and the formation of grassy plains, which we know went on steadily, especially through the last third of the Tertiary era. The short, massive legs and spreading, five-toed feet, useful in sustaining an animal's weight in marshes, were slowly changed to longer, more slender limbs and a digitigrade walk as greater speed and nimbleness were required in making their way over wide pastures to and from watering places

or in escaping the beasts of prey, which were themselves becoming swifter and more active in jumping by a coordinate evolution of abilities. But before proceeding to the typical hoofed tribes, mention must be made of the elephants, which belong in this order. Elephants appear to stand apart from all



THE SOUTHERN MAMMOTH

Drawn by Christman. (American Museum of Natural History)

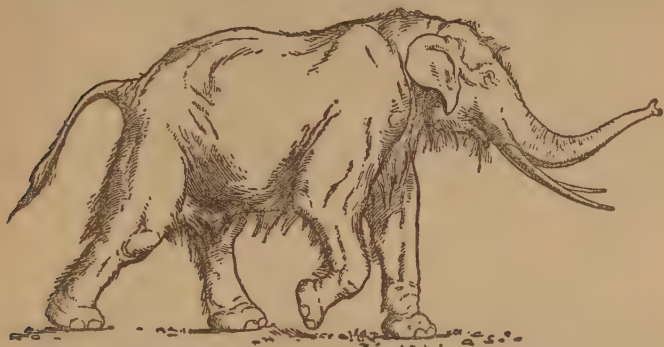
other mammals, and from the earliest times have attracted attention by their huge bulk and strength, and by traditions of their intelligent performances. They seem a necessary part of our ideas of Oriental life and grandeur, and a circus without trick elephants would be a poor show in the eyes of the American youngster.

The naturalist classifies them (order Proboscidea) in this place because they are plainly, although remotely, related in structure to the solid-hoofed browsers; but only recently has he been able to trace their ancestry back to a small, tapirlike forefather

of Miocene days, with no trunk and no tusks. The trunk, of course, is the animal's lengthened nose, become an organ useful for many purposes other than breathing; and the tusks are overgrown upper incisor teeth. The elephants of the present time are few compared with those of warmer past ages, when many species, as well as various cousins, such as long-haired mammoths and towering mastodons, wandered over Europe, Asia, and our own country. Now only two kinds remain: one in Africa, the other Asiatic. They differ in many ways, most noticeably in the size of the ears, which in the African elephant are very much larger than those of the Asiatic species. Both are forest animals, feeding on leaves and twigs. African elephants were formerly to be found all over the wooded parts of that continent, traveling about in herds that sometimes numbered a hundred or more individuals; and were varied in appearance, some being taller than any Oriental one, while others (in the Congo region) are so small as to be called dwarfs. The natives have never captured and made use of them, and few have been tamed by anyone within recent years, but in the time of the Carthaginians and Romans they were held captive, ridden, and employed in war, and in sports of the arena. They have been greatly reduced in numbers by ivory hunters, and would be nearly or quite extinct now had they not been protected in recent years by wise laws.

The Asiatic, or "Indian" elephant, which is confined to India, Ceylon, Burma, and the Malay countries, still roams the jungles as a wild animal, but every herd is known to and protected by the local governments, and from time to time these are rounded up, and young ones are captured and

trained to man's service. Only in this way can the domestic supply be maintained, since these elephants rarely produce young when in captivity. They are utilized as riding and burden-bearing beasts, for hauling heavy loads, especially in the army service, and in handling large timber and



PREHISTORIC STRAIGHT-TUSKED ELEPHANT

Drawn by Christman. (American Museum of Natural History)

other industrial operations. Some ivory is obtained from this species, but the tusks are far smaller than those of the African elephants, and the females bear none at all, while both sexes are armed in Africa, where an old "bull's" tusks have been known to exceed a weight of 300 pounds each.

Although there is no reason to suppose the African elephant is less intelligent by nature than the Oriental one, nearly all the evidence of thoughtfulness in these animals comes from Indian examples—a species that has been studied and educated for hundreds of years. That they may be taught to do almost anything of which their bodies are capable is plain; but undoubtedly they comprehend very largely the purposes of the man directing them, and use

"brains" in assisting him to carry them out. They have retentive memories, appreciate kindness, and constantly show skill and discretion in accomplishing what they are asked to do. In regard to no other sort of animal has so much been written as of elephants; and the sum of the testimony is that they are not only very teachable and faithful in performing their tasks, when not disabled by fear, but often use surprisingly good judgment in their work.

Distantly related to the elephants, yet so remote in relationship to anything else as to be set apart in an order (Hyracoidea) by themselves, and with no visible geological ancestry, are the queer little "conies" of the Scriptures, called rock rabbits, and dassies in South Africa. They have a singular resemblance to rabbits, apart from their little round ears, and are more like enlarged copies of our western pikas, but their anatomy and teeth show they are far from being rodents; and they are classified here mainly by reason of their rhinoceroslike teeth, and the hooflets on their toes, so that they form a quaint intermediary between the elephants and the solid-hoofed section of the ungulates; they are, indeed, relics of an exceedingly primitive and ancestral type of ungulates.

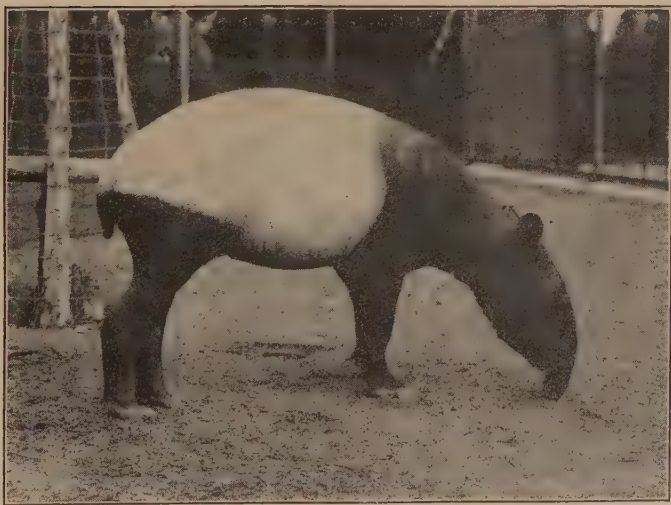
#### RHINOCEROSES, TAPIRS AND HORSES

Included by their general anatomy among the perissodactyls, although they have several toes on each foot, all reaching the ground, and, like those of elephants, connected by webs and clothed with thick, hooflike nails, are the rhinoceroses and tapirs. The rhinoceroses are relics of a long and interesting geological history. Two belong to Africa, one of which, the common "black," browsing rhinoceros, is



Photo, Elwin R. Sanborn, N. Y. Zoological Society

WART HOG, ONE OF THE UGLIEST ANIMALS TO SEE



Photo, Elwin R. Sanborn, N. Y. Zoological Society

THE MALAY TAPIR, RELATED TO THE PIG AND THE RHINOCEROS



MARKHOR, AN ASIATIC WILD GOAT



PHOTOS, ELWIN R. SANBORN, N. Y. ZOOLOGICAL SOCIETY  
MOUNTAIN SHEEP OR BIGHORN OF THE  
ROCKY MOUNTAINS

still abundant south of the equator in all the more open and less occupied parts of the continent; while the other, the larger, square-lipped, grass-eating, or "white" rhinoceros, has become very rare save in certain remote and upland plains. Both have thick, hairless skins of a pale lead-gray, which lie smoothly over the whole body, and both have, on the nose, two horns, composed of matted, whalebone-like hairs, not a part of the skeleton but springing



BROAD-NOSED RHINOCEROS

Merck's Rhinoceros—prehistoric. Drawn by Christman. (American Museum of Natural History)

from the skin. The front horn is always much the longer, in some cases reaching a length of more than fifty inches. Asia has three species of rhinoceros, all of which differ from the African in having functional incisor teeth, and in their hides. The best known is the "Indian" rhinoceros, now confined to the hot jungles of the extreme northeast of India. It has only one horn, and its dark hide is thrown into heavy folds looking like artificial armor. It became known to Europe early in the sixteenth century, and became the subject for some of the most curious speculations and superstitions of that credulous age. The "Sondaic" or hairy rhinoceros still is to be found in jungles from Bengal around to the

end of the Malayan Peninsula. It is smaller than the Indian one, and its folded and tessellated hide supports a coat of short hair; its horns are only two little protuberances on its nose. Finally Sumatra and Borneo have a rhinoceros whose coat is still more hairy, and among whose peculiarities is the possession of two formidable horns. These creatures are perhaps the best examples remaining of what Merck's rhinoceros (fossil) and other big quadrupeds of the Pleistocene era looked like.

The tapirs are even more widely separated in habitat than the rhinoceroses, for four species dwell in the New World between Guatemala and southern Brazil and Guiana, while the fifth belongs to Malaysia. They are forest animals, and mainly browsers, the long, almost trunklike nose and lips enabling them to seize and tear off leaves and twigs easily. They choose low districts, as a rule, and rush into the safety of water when in danger from the jaguar or other beasts. They are shaped somewhat like a very fat pony, but with a big, pointed head, and are clothed with short hair of plain dark tints, but the young are spotted at first. They are timid, secretive and nocturnal in their habits. Their flesh is excellent meat.

This brings us to the horses, whose geological history is one of the romances of natural history, as it is traced from the little five-toed eohippus of the Eocene up to the herds that roamed our western prairies, and disappeared so completely, and so unaccountably, in the era just preceding the present. Our domestic horses, consequently, are all of Old World origin. As far back as man can be traced in his supposed birthplace in central Asia herds of small horses fed upon those high plains; and about

fifty years ago bands of ponies were discovered ranging the dreary deserts of Dzungaria, or north-western Chinese Turkestan, and specimens are now living and breeding in the Zoölogical Park in New York and in European collections. This truly wild horse stands about ten hands high, and is covered with thick hair of a dull brown color, unstriped.

Such horses were undoubtedly hunted and killed as food by Paleolithic men; and when, many, many thousands of years ago, they had in some degree domesticated them, and began to migrate southward and westward, they took these horses with them. Those people that gradually occupied Persia, Mesopotamia, and the plains of Arabia and North Africa, developed them into riding animals that became perfected in what we know as the Arabian horse. Those tribes that migrated across Russia and along to the northern shore of the Mediterranean, found in Europe a similar, but more robust horse, now designated the "forest" horse, which the savages regarded as game. The two interbred in the course of time; but the southern breeds have remained smaller, lighter, and more agile, while the northern or forest stock has been the foundation of the heavy draft horses of northern Europe. After the Crusades Arab blood was introduced to effect a still further refinement of the horses of southern Europe, and it was from this Arab-improved stock, prevalent in Spain, that the horses sent to the Spanish colonies in the Americas were derived. Our plains, and the pampas of South America, soon became populated with these horses run wild—"mustangs," showing even yet traces of their aristocratic lineage.

So near to the horses that they belong to the same genus (*Equus*) are the zebras, which differ mainly

in their brighter coloring, less bushy tail, "roached" manes, and lack of those callosities called "chestnuts" on the hind legs. The zebras are exclusively African, and include two types, a southern and a northern. The true zebra, now extinct, except where kept and bred in captivity, belonged to the mountains near the Cape of Good Hope, was only about twelve hands high, and had black stripes on a white ground.

In the more open parts of Africa, north to Lake Rudolph, roamed Burchell's variety of this zebra, the one now commonly seen in menageries, in which the coat is creamy or golden yellow, and the black stripes are far broader. Its northern variety, Grevy's zebra, has the black stripes narrower, but so much more numerous that the white shows as mere lines between them. To these must be added an extinct species, killed off many years ago by Boer farmers and other sportsmen, which was known as the "quaha" (quagga) from its barking neigh; it was a dark brown, with stripings only on the head and neck.

The zebras seem incapable of becoming useful in harness or under the saddle, but their very near relatives, the asses—in spite of the sober gray of their dress, and their ungainly ears—have given us the patient and enduring donkey, which has been a servant of mankind, at least in Egypt, ever since the date of the earliest monuments; and wild asses still flourish on the deserts of Africa from Algiers to Somaliland. Another somewhat larger and more variable species roams the upland plains of Persia and northern India, while a variety, the "kiang," lives on the arctic tableland of Tibet, and is as untamable a creature as can be imagined.



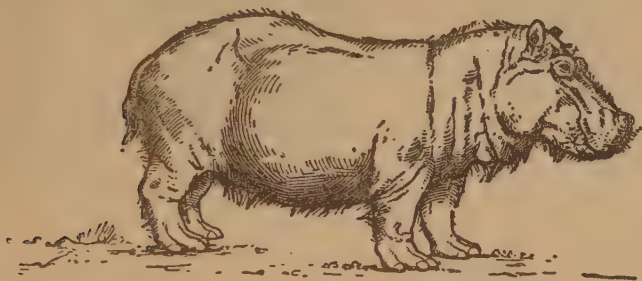
BURCHELL'S ZEBRA OF NORTHERN CENTRAL AFRICA

## HIPPOS, PIGS AND CAMELS

With the hippopotamus we begin the long list of artiodactyls, or cloven-footed animals, in which the weight of the body rests equally on the two central digits (third and fourth) which are alike in development, while the second and fifth digits, when present, do little or no work, except in the hippopotamus, whose outside toes are as long as the central ones, because needed by an animal treading on muddy soil, and accustomed to swimming. Although this huge marsh denizen is now confined to Africa, it ranged into southern Europe and eastward to India within quite recent times, but was destroyed by the human settlement of these countries; and civilization will in due time exterminate it from the Congo and Nile basins where it now is so numerous, and so incompatible with commerce and industry.

The swine are the first artiodactyls to show the typical cloven feet, and in them the two hind toes reach almost to the ground, so as to help the footing in the soft ground that they frequent. The foremost member of the family (Suidæ) is the wild boar of the Old World, known from the North Sea to the Bay of Bengal; and it is hard to realize that the fat hogs of our stockyards are modifications of this bristling forest boar with his muscular form, swift gait, and terrible tusks. Far more ugly in appearance, however, is the wart hog of Africa and the hairless "babiroussa" of Celebes, whose up-curved tusks far outmeasure those of the Indian boar. America has a family of native swine named pecaries—small, thin-legged, grizzled-black pigs, with very thick, bristly necks and large, angular heads. They have wicked little eyes, razor-sharp tusks in

both jaws, and no visible tails, and the young are not striped as in the typical *Suidæ*. These pigs go in companies, wandering mainly at night in search of food, and taking almost anything edible. They are irascible, attack with fierce energy in concert, and are formidable foes to anything afoot, driving even the jaguar up a tree when the band turns on him.



PREHISTORIC HIPPOPOTAMUS

Drawn by Christman. (American Museum of Natural History)

One kind of peccary is common in southwestern Texas, and its roving bands do much damage by night to crops and gardens; it is called a "javelin."

The swine occupy a somewhat intermediate place between the solid-hoofed and the split-hoofed sections of the *Herbivora*; and the stomach is simple except in the peccaries, where it takes a complicated form that approaches that of the ruminants. This simplicity, with the correlated fact that swine do not chew the cud, enabled the leaders of the ancient Hebrews to set pigs apart, as unclean, by a more general definition than a mere name could give, thus leaving no way of escape for those who might be inclined to dodge the prohibition by quibbling. All other *Herbivora* are ruminants, that is, chewers of the "cud"—those that gather and swallow their food

in haste, and then at leisure recover it and thoroughly rechew it in small quantities (cuds).

This strange operation, like the carrying away of food by pocket mice, monkeys, etc., enabled these comparatively defenseless animals to gather nutriment in a short time and then retreat to a safe place to prepare it for digestion. Associated with this practice is a large, complicated stomach, normally consisting of four chambers, into the first and largest of which the hastily swallowed forage is first received. Then, when swallowed a second time, it passes on into the second or true stomach, where real digestion begins.



Photos, Elwin R. Sanborn, N. Y. Zoological Society

AT THE LEFT, THE KUDU, OR STRIPED ANTELOPE OF AFRICA; AT THE RIGHT, HEAD OF THE GREATER SABLE ANTELOPE



Photo, American Museum of Natural History

HEAD OF AN ALASKAN MOOSE



Photo, Elwin R. Sanborn, N. Y. Zoological Society

AXIS, OR SPOTTED DEER OF THE EAST INDIES



Photo, Elwin R. Sanborn, N. Y. Zoological Society

AMERICAN DEER WITH HORNS IN "VELVET" STAGE

## CHAPTER XXXI

### THE WORLD'S HERDS AND FLOCKS—

*Continued*

#### CAMELS, DEER, GIRAFFES AND PRONGHORNS

THIS is a rather miscellaneous group introducing the typical Herbivora. The most ancient of them in the style of their structure are certain little spotted creatures, like miniature deer in appearance, that inhabit the forests of western Africa and the Orient, and are known as chevrotains. The fact that in their metapodial bones they resemble the structure of camels causes these apparently so distant animals to be placed next to camels in classification.

The history of the camels (Camelidæ) is very similar to that of the horse. The family originated in North America, where it developed from little creatures, by changes and adaptations to a life on dry uplands, as did the horses, into a species which in the Pleistocene was a third larger than any now living. Meanwhile camels had made their way over the land which in the later Tertiary connected Alaska with Siberia, into the high plains of Asia, where the camels found favorable circumstances and developed into the two species we know. Others migrated, earlier in the family history, into South America, where they ceased to grow tall after the camel model, but became the huanacos of Patagonia, of which the llamas (yah-mas) are prehistorically domesticated descendants, and into the woolly vicuñas of the Andean mountains.

Modern camels are of two kinds—the single-humped and the double-humped. The latter, or “Bactrian,” is confined to Asia, and is able to endure the cold and snows of the tablelands of that continent, where its burdens are carried in winter as well as summer. What was the extent to which the



LLAMA

*(Lama peruviana)*

A domesticated animal of South America

single-humped, or ordinary camel, ranged before its prehistoric enslavement by men, we do not know—if it roamed the deserts of Arabia and northern Africa as well as those of Turkestan, no evidence of

it remains. A few small-sized, gaunt, wary, and swift-footed camels still run wild among the almost inaccessible sand dunes of the Gobi Desert, but it is not certain that they are relics of the original wild



BACTRIAN CAMEL

(*Camelus bactrianus*)

The two-humped camel of Asia

stock. At any rate the camels have always been creatures of the world's waste places, and all their quaint peculiarities such as their sole pads and the water-storing sacs in their stomachs (rumens) are adaptations to their desert home.

The deer family (Cervidæ) is of great extent, and worldwide in its distribution, except that it is entirely absent from Africa and Australia. In none are more than two toes of use in walking, the second and fifth toes hanging at some distance behind and above the functional hoofs, which are narrow and pointed. All have slender, long legs, giving

swiftness and great leaping power; and very short tails, with the exception of the rare and peculiar David's deer of China, whose tail is almost like that of a cow. The coat of hair is short and brittle, reddish brown or foxy in summer, grayer in winter, in some species plain, or spotted only when fawns, in others variegated with small, whitish spots. The distinctive badge of the family, however, is the pair of horns borne on the heads of the males (also by females in the reindeer and caribou), collectively and more properly called "antlers," since they are not composed of horn, but of true bony material. They are poised on two protuberances on the top of the skull, where in spring arises a growth of fleshy material, covered with velvety hair, that rapidly takes the shape of the antler characteristic of the species (and age) of the deer, and as it grows is filled with lime salts that gradually replace all the tissues. Then the "velvet" dries and scales off and the ivory-like antler emerges. This remains as a serviceable weapon and ornament of the buck until the beginning of winter, when its attachment to the skull loosens, and the antler drops off. This happens annually in the case of all deer—one of the common and universal facts in zoölogy that many find it hard to believe. The "horns" of the various deer vary in size from short and simple "spikes" to the wide-branching antlers of the moose and wapiti; but these last are acquired only when the buck is fully matured, the yearling showing only a spike, and acquiring branches ("tines") one by one annually as he grows until his proper complement is reached; but in a few small species no branching ever occurs.

The family contains many genera and species, but only the most noticeable can be mentioned. The

most familiar one, probably, is the small, spotted fallow deer of southern Europe, bands of which ornament the parks of grand estates in Great Britain and on the continent; its antlers broaden at the end into the form known as "palmated," on account of its resemblance to an open hand with fingers. Even more celebrated in song and story is the red deer, the males of which are "stags" and the females "hinds." These are large, dark, reddish brown animals, with grandly symmetrical antlers, every tine or "point" on which—seven on each side in a "full head"—has its name in the language of hunting. This deer, still wild in the highlands of Scotland and in the mountainous forests of eastern Europe, is also to be found right across Asia, where local varieties go by the names of "maral" in northern Persia, "hangul" in Kashmir, and so on to eastern Siberia, where far taller species live than are known to Europe; and all vary in minor particulars only from our wapiti—which it is fair to regard as of the same stock.

None of all these stags is more stately than the American wapiti—the "elk" of all western men—which once abounded from the Adirondacks and southern Alleghenies to California and the borders of Alaska. Everywhere of old it was plentiful and easy to kill, and the pioneers swiftly destroyed it as civilization was pushed westward, until its mighty herds have vanished almost as completely as those of the bison. It thrived anywhere and everywhere, climbing the wooded heights of the Appalachians (where the very last one was killed near Ridgway, Pennsylvania, in 1869), loafing in the warm, well-watered valleys of the Mississippi basin, herding in the sun-baked plains, or scrambling up and down

the roughest of western sierras. Equally broad in its appetite, those that browsed or ate mast and fruits in the eastern woods did no better than those which grazed on the bunch-grass plateaus from the Rio Grande to Peace River; and in winter it would keep fat where other deer or cattle might starve, because able to paw through the snow to the dried grass.

The other round-horned deer of the United States are the familiar Virginian, white-tailed, or willow deer, which is to be found all over the country, and in similar species in Mexico and Central America; the larger black-tailed, long-eared "mule deer," or "jumping deer," of the plains and the foothills of the Rocky Mountain region, and the small, forest-keeping, black-tail, or Columbian deer of Oregon and northward.

Canada, Alaska, and the northern parts of Maine and Minnesota, are the refuge of that biggest of all the deer, which we call by the Indian name "moose," but which is known to Europeans as "elk," for it is a circumpolar species that once roamed in great numbers through the woods of all Europe, and in this country far southward along the Appalachians. Until the World War the elk was preserved in certain large forests of Lithuania and central Russia, but it is doubtful if any survived the desolation of that region during and after the war. The moose is everywhere a forest-ranging animal, especially fond of regions where rivers and lakes abound, in which it finds desirable food in summer and takes much pleasure; yet in the mountainous West it often climbs to high and dry heights. Its principal diet is leaves and twigs, pulled off by the long, flexible lips that are so characteristic a feature. The moose is a huge, immensely strong and ungainly animal,

blackish brown with pale legs and belly, and with a neck so short that it can graze only by kneeling. A very large bull may stand six and a half to seven feet high at the withers, which, with the neck, are clothed in a thick mantle of long, coarse, stiff hair; and from the throat hangs a long hairy strip of dewlap skin (the "bell"), which in old age draws up into a sort of pouch. The long and narrow head ends in an overhanging, flexible muzzle, that may be curled around a twig like a proboscis. On this massive head and neck the bulls carry a wonderful pair of flattened antlers, always surprisingly wide



REINDEER CROSSING A STREAM

From a prehistoric engraving on an antler found in southern France

in spread, but varying greatly in weight, and that irrespective of the relative bigness of the animal. The moose of the Kenai Peninsula, Alaska, are famous for the immensity and complication of their horns; one pair preserved in the Field Columbian Museum, Chicago, have a spread of seventy-eight and a half inches, show thirty-four points, measure fifteen inches around the burr, and with the dry skull weigh ninety-three pounds; but very few reach such dimensions.

Another flat-horned deer is the famous reindeer of the boreal regions of both hemispheres, for our

arctic caribou are the same animals under another name. No truly wild reindeer now exist in the Old World, but they are scattered over all the Barren Grounds, or treeless coast areas and islands, from Greenland to Alaska; and the Eskimos depend on them not only for food to some extent, but even more for clothing and tentage. Every autumn enormous herds of these caribou, gathered in migration, sweep southward to less frigid and snowy feeding grounds in the region between Hudson Bay and Great Slave Lake, and there enable the Indians to provide themselves with meat and skins for the winter. These arctic caribou feed mainly on the lichen called "reindeer moss." Another kind, the "woodland" caribou, inhabits the uncivilized forest borders south of the Barren Grounds, and the mountain region from British Columbia to the arctic shore of Alaska and Yukon; and in the east occurs in Ungava, Labrador, Newfoundland, and New Brunswick. They are not regularly migratory, but wander in small herds, prefer swampy woods, and their habits approach those of the moose. There is no great difference otherwise between them and the arctic caribou; but they vary a good deal, so that several species have been named among those of the west, one of which, in Alaska, is quite white.

Southeastern Asia has many kinds of deer, such as the large staglike sambar of India and eastward; the spotted axis, or chital; the sika of Japan; and a variety of small Oriental species exist.

The giraffes of equatorial Africa (family Giraffidæ) are closely related to the deer. They are hornless, but from the top of the skull project two protuberances, several inches in length, which answer to the horn-cores of the deer, but carry no antlers, and are

permanently covered with hairy skin; between them is a third shorter protuberance of the skull. A few years ago it was discovered that there existed in the dense forests of the lower Congo valley an animal



OKAPI

(*Okapia johnstoni*)

A relative of the giraffe, found in the forests of Africa

of this family, but smaller and more antelopelike in body, and without the towering characteristics of the giraffe, called by the Pygmies of that district "okapi" or "o'api." It is chestnut in color, with

yellowish cheeks and the legs marked with wavy, whitish stripes. It is perhaps not rare, but is exceedingly difficult to obtain in the dense jungle it inhabits.

Two singular animals remain to be mentioned here, as standing intermediate between the deer and the cattle family, next to be considered. One of these is the musk deer of the Himalayas, from which is taken the "pod," or ventral gland, that contains the odorous substance "musk." This is a strange, old-fashioned, solitary little creature, the size of a half-grown kid, and having very large ears, almost no tail, and no horns, but wearing a pair of keen weapons in the long upper canines which hang well down below the lower jaw. The four toes of the feet are almost equal, and the hoofs so free that they can fairly grasp any projection, so that the animal is a marvel of agility and sure-footedness.

Our American pronghorn "antelope" is the second of these intermediate animals, and is not far removed in its structure from our white mountain goat. It foreshadows the sheathed-horned ruminants, but differs from all of them in the fact that its horns bear a prong, and also in that they are periodically shed and renewed. This beautiful and graceful little animal, truly antelopelike in form and habit, stands about three feet high at the shoulder, has slender legs and feet, with no false hoofs, and is exceedingly swift in its bounding gait. It is now almost gone from the wide plains where only a few years ago it was to be seen in summer from the Saskatchewan to the Rio Grande and southward. In the autumn it would gather in the North into ever-increasing herds that swept southward to pass the winter in Texas and New Mexico, and then would

return northward with the advance of spring. The extension of fenced ranching, but most of all the spanning of the plains by railroads, rapidly put an end to these migrations, and the wasteful killing of the pronghorns in sport, or as food, completed the virtual extermination of one of the most interesting and desirable animals of the New World.

## CHAPTER XXXII

### SOME SUPREMELY USEFUL ANIMALS

THE fact that likeness of structure, which compels naturalists to group certain animals into a family in spite of possible unlikeness in size or form, is accompanied by resemblance in quality, is well illustrated by the family Bovidæ (Latin *boves*, "cattle") which includes goats, sheep, antelopes, and oxen; for all of these in flesh, products and disposition, are alike suited to the requirements of men, and especially of mankind in a social civilization. This family of animals furnishes us with nearly all of our milk, butter, and cheese; with flesh food, woolen clothing, leather goods, horn, gelatin, etc.; and gives us such servants as the ox and goat; while sportsmen find in it the most fascinating of their larger game.

The distinctive feature of this most useful of animal tribes is the possession of hollow horns, properly so called. Horn is a chitinous material developed from the skin, and not dissimilar to hair; indeed it would be no great stretch of facts to say that a cow's horn was composed of agglutinated hairs. These horns are sheaths that grow over cores of bone—outgrowths of the skull—increase in size until their wearers are mature, grow at the base as fast as worn at the tips, and are never shed. They may be borne by the males alone, or by both sexes; or the males may have horns far larger than those

of the female, as in the sheep; and in a few cases both sexes are hornless. No family is more difficult to subdivide, for the various forms intergrade inextricably.

Our mountain goat, or "mazama," which dwells on the snowy heights of the Pacific Coast ranges, from southern British Columbia to farthest Alaska, is one of these intermediate ones, suggesting both goat and antelope in its make-up. It is about the size of an ordinary domestic goat, has small, sharp, black horns, and is clothed in long white hair with an undercoat of wool fitting it for the wintry cold in which its life is spent, for except in midwinter it never comes below timber line, and even then avoids the wooded places. In the rough mountains of Japan lives a similar goat antelope, woolly, but not white; and the lofty heights of western China is the home of a smaller one, the goral, and the Himalayas have the big serow. All these have short, sharp horns rising from the top of the skull. Their nearest western neighbor is the famous chamois of the Alps and Carpathians of Europe. The extraordinary agility of these mountaineers is possible because of the pads beneath their hoofs that give them the clinging surefootedness which is so remarkable.

Most closely allied to them, probably, are the goats, also denizens of mountain regions, the typical species being confined to the highlands between the Caucasus and northwestern India. This is the true goat from which the domestic goat is descended; but the long-haired "Angora" goat is derived from the markhor, a sheeplike animal of the Himalayas with tall, much twisted horns. One of the special characteristics of the goats (genus *Capra*) is the beard of the rams; and this feature belongs also to the ibexes,

several similar species of which are found from the Pyrenees eastward along the mountain tops to northern China, each occupying a limited section of country, and one inhabiting the mountains about the head of the Red Sea. That of Spain is called "bouquetin," and that of the Alps "steinbok." All the rams possess great horns, sometimes fifty inches long, that rise from the occiput, curve backward, and show on their fronts a series of prominent cross ridges. One passes from these goats to their near relatives, the sheep, by way of the "bharal" (or "burrel") which combines the characteristics of the two sections so thoroughly that the proverbial "separating the sheep from the goats," easy enough on the farm, is practically impossible among wild flocks. In this crag-loving wanderer the horns of the rams are as long as those of an ibex, but roundish and wide spreading, instead of upright and cross-ridged. The "aoudad," whose home is in the mountains of Morocco and Algiers, and which is familiar in menageries, has such horns, but approaches nearer in other respects to the typical sheep, whose rams carry the great spiral horns at the side of the head, that are still the pride of our domestic merinos, and were the badge of the Theban god of gods, Ra Ammon. No better example of these magnificent mountaineers, which under one or another of several specific and local names, such as argali, oorial, etc., are, or were, to be found on rough highlands all the way from the Mediterranean to Bering Sea, can be shown than our own "bighorn" sheep of the Rocky Mountains, and of the mountains of Canada and Alaska.

Now we come to the great and beautiful section of the antelopes, in which naturalists recognize

thirty-five genera and perhaps a hundred species. Antelopes were scattered in Pleistocene days all over continental Europe and Asia, but never were present in America, for our so-called "antelope" is a pronghorn, as has been explained. Two or three species now inhabit the plains of central Asia—among them the swiftest mammal known, the Mongolian "orongo." The ungainly "nilgai" and the little "black buck" are familiar in India, and the pretty dorcas gazelle races across the sands of Syria and Arabia; but the vast majority of antelopes belong to Africa. They range in size from the duikerboks, not much bigger than fox terriers, to the eland, which has almost the bulk of an ox, and should be domesticated, like beef cattle, for its excellent flesh. No handsomer mammals than antelopes exist, judged by either form or coloring. They inhabit all sorts of country, too, as in other lands do the deer, of which Africa has none. Deserts, such as the Sahara and the Kalahari, and the stony steppes of Somaliland, support not only the swift and agile gazelles, but several large kinds. The grassy plains of South Africa were formerly, and to some extent still are, the pastures of great herds of such antelopes, large and small, as blesboks, wildebeests (or "gnus"), hartebeests, steinboks, springboks, and many others. Springboks used to assemble at certain seasons, and migrate across the veldt in countless thousands, allowing nothing to stop the headlong rush of the host. The thick jungle is the refuge of the harassed antelopes, and of several diminutive kinds rarely seen in the open; and along the watercourses, and in marshes, live the big red waterbucks, the shy sitatungas, whose feet are curiously modified to fit them to walk on boggy ground; while rocky hills are

the chosen home of the klipspringers and duikerboks, agile pygmies that creep about among the brush like big rabbits, or leap from rock to rock like miniature goats. A score or more of the species of these beautiful creatures have been carelessly or wantonly exterminated, and many others have become rare, but protective laws are now in force in all the parts of Africa controlled by the Government of South Africa, or organized as British, French, or Belgian dependencies.

The quant and complex musk ox, a lone relic of a past era now exiled to the remotest north, is a connecting link between the sheep and the cattle, the last and best of the ruminants. Here, as elsewhere, the style of the horns is characteristic of the group—slender, backward curved or twisted, and somewhat compressed or keeled, in most antelopes; heavy, cross-ridged, triangular in section and often spiral in the sheep and goats; rough and helmetlike in the musk ox and some buffaloes; and in the oxen round, smooth and always springing from the side of the skull. The cattle fall into three groups: buffaloes, bison, and oxen.

The buffaloes are tropical cattle, usually heavily built, with massive, flattened, wrinkled horns, and the hair so thin that in old animals the bluish black skin is left almost naked. The typical buffalo is that native to India and Ceylon, where it formerly roved in herds, which, quickly forming into a compact bunch, heads and horns out, defied attack from even the lion or tiger. Bulls often exceed five feet in height, are extremely strong and quick, and carry rough horns, sweeping back circularly, which may measure twelve feet around the curve. Such a veteran herdmaster spends his days wallowing in

marshy jungles, his broad, splayed hoofs sustaining him in the muddy soil, and his hairless back, coated with clay, proof against insects; but evenings and mornings he leads his band out to feed in lush prairies where the grass is tall enough to hide them. This is the race that has supplied the working cattle of hot, swampy regions, especially where rice is grown, and that has been the farmer's servant in the Far East, in Egypt, and in parts of Spain and Italy from time immemorial. Several breeds have been developed, of which the best known to Americans is the carabao of the Philippines. Africa has native buffaloes in two species, neither of which has been domesticated. The African buffalo is regarded as perhaps the most dangerous brute a sportsman can meet in that land of irritable beasts. Only rarely will even the lion attack one single-handed, and then seldom succeeds.

The bisons, although regarded by systemists as of two species, the North American "buffalo" and the European "wissent," are as nearly alike as well can be. The latter originally ranged over all Europe, and was necessarily a forest animal, and hence never could assemble into herds as did its American cousins. It has been protected on the Czar's and other great estates in Lithuania and Russia, to the number of about 700; but these preserves were ravaged during and after the World War. The wanton waste that swept away the millions of our American bison in a few short years would long ago have exterminated this species also had it not been preserved in bands here and there in the West and in various animal collections. The peculiarity of the bison is the massive, humplike strength of the fore quarters, the great mop of hair upon them and

about the head, and the short, stout horns growing straight out of the side of the head.

The animal called "bison" by sportsmen in India is the gaur, one of four species of true oxen inhabiting southeastern Asia—heavy animals with massive, up-curved horns, a long, ridgelike spine, short tail, and fine, glossy, dark-colored hair. A big bull of the gaur or "sladang," as Malays call it, will stand six feet tall at the shoulders, and is one of the greatest game animals of the world in every sense of the word. Celebes has a curious dwarf ox, the "anoa," which is hardly bigger than a goat. Contrasted with this is the great ungainly yak of Tibet and the high Himalayas, where it still wanders in a wild state, although large herds are kept by the Tibetans as beasts of burden in a region where hardly any other large grazer can exist. Finally, the Orient is the home of an extraordinary race of ancient domestic animals, the white, humped cattle of India, of which many breeds exist, modified by local conditions and purposes, and prehistorically used in Egypt and probably southward. No wild animals of its kind exist, and we know nothing of the origin of the race.

We now come to the most interesting species of the family, now extinct as a wild animal, but perfectly traceable—the primitive wild ox of Europe, the original of our farm cattle. It was much larger than any modern breed, and bore immense, wide-spreading horns, as still do certain coarse breeds in southern Europe, and especially in Spain, whence the herds of long-horned cattle of America were derived. Old bulls were black, but there is reason to suspect that the cows and calves may have been red. This great animal roamed throughout Europe

and western Asia, and was counted among the fiercest of game in Cæsar's time, who found it called "ur," or "aurochs"; the former word was Latinized as *urus*, and the latter, when this ox had disappeared, became transferred to the bison. Even in Roman times the wild ox was growing scarce, and it died out early in the seventeenth century. Meanwhile, from prehistoric days, calves have been tamed by the peasantry, and such cattle as Europe and the Mediterranean basin generally possessed were until quite recently little better than rough descendants of this captured stock.

The so-called "wild white cattle" preserved in various British parks are, according to Lydekker, albino descendants of the tamed native black aurochs stock, of unknown antiquity, and are kept white (with blackish or reddish ears and muzzles) by weeding out the dark-colored calves which occasionally appear; but do not represent the original aurochs as well as do the Welsh breed preserved in Pembroke since prehistoric days. These park cattle are all of moderate size, elegantly shaped, with soft hair, white, black-tipped horns of moderate length, and many wild traits.

## CHAPTER XXXIII

### BEASTS OF PREY—THE CARNIVORA

“ONE of the most striking and significant results of the study of the later Mesozoic and earliest Tertiary mammalian faunas,” remarks Prof. W. B. Scott, “is that the higher or placental mammals are seen to be converging back to a common ancestral group of clawed and carnivorous or omnivorous animals, now entirely extinct, to which the name of Creodonta was given by Cope. The creodonts are assuredly the ancestors of the modern flesh-eaters, and, very probably, of the great series of hoofed animals also, as well as of other orders. From this central, ancestral group the other orders proceed, diverging more and more with the progress of time, each larger branch dividing and subdividing into smaller and smaller branches, until the modern condition is attained.”

The story of the creodonts—savage marauders large and small—includes the rise of the powerful order Carnivora—the beasts of prey, whose food is the flesh of other animals. There always has been, and always will be in every department and rank of animal life, some or many species that live by preying on their neighbors; and every living thing, from monad to man, has to fear such enemies.

The essential characteristic of the Carnivores is the dentition, which is adapted to seizing, holding, biting, and cutting. The canines, rarely prominent

in other groups, here become of prime importance—a dagger and hook in one—a tearing instrument. Naturally this tooth is most developed in the dogs and the bears, which have little other means of seizing and holding an animal, whereas the cat has efficient aid in its claws. The cheek teeth in this order are (typically) not flat “grinders” but angular and knife-edged, especially the foremost molars that shut past one another like scissor blades; and it is evident that such teeth are necessary to animals that must cut their food into pieces small enough to swallow, and are not concerned about chewing it. The order contains two distinct divisions, namely:

*Marine Carnivores*—Seals, sea lions, walruses.

*Land Carnivores*—Cats, dogs, weasels, bears, etc.

The marine carnivores (suborder Pinnipedia, “fin-footed”) have their whole organization adapted to an aquatic life, and appear to have acquired it almost from the beginning of the diverse specialization that sprang from the generalized creodonts, for nothing is known of their ancestry that connects them with the known lineage of their kin on land. The body approaches a fishlike form, and the four limbs are turned into more or less perfect paddles, or “flippers.” The teeth are of the carnivorous type; the eyes are always large and prominent; and external ears are lacking except in one family.

The least modified of the three families of marine carnivora is that of the eared seals—the sea lions and fur seals of the North Pacific ocean, and southward to Cape Horn. They have kept much independence of action in the hind limbs, and are able to climb readily about the rocks of the islands and shores to which they resort in midsummer for the

birth of the young. They have an obvious neck, small external ears, nostrils at the tip of the snout, and in general more characteristics like those of land carnivores, especially the bears, than have any other pinnipeds. They live wholly on fish. Several species termed "sea lions" were formerly numerous from Oregon southward to Patagonia, and on certain South Sea islands, but they have been all but exterminated except in California. These southern species, dwelling in warmer latitudes, are known as "hair" seals, because their coat lacks the warm undercoat of the northern species (*Otaria ursina*) which is the "fur" seal of commerce, and which would long ago have disappeared had it not been placed under international protection in its breeding places on islands in Bering Sea. Thither, as summer opens the ice, gather the herds that have been wandering in the ocean during the winter. The females are much the more numerous of the two sexes, and having spread all over the islands, formerly in hundreds of thousands, are collected into "harems." The "bulls" are three times the size of any of the females, and there are incessant combats between rival bulls. The young born here are strong enough to swim away with their mothers in the early autumn.

Similar in general organization, and in the freedom and usefulness of the hinder limbs for creeping on land or ice, are the walruses (*Trichechidæ*), of which there are two arctic species, one in the North Atlantic, and one in the seas of Alaska and Kamchatka. In old times they came as far south in winter as Nova Scotia and the coasts of Britain. A full-grown male walrus is a very bulky animal, ten to twelve feet long, and his skin is covered with a short coat of hair that in old age almost disappears,

while his bulldoglike muzzle bristles with quill-like whiskers. The especial feature of the walrus, however, is the pair of great ivory tusks, often two feet or more long, which are the canines of the upper jaw. They are the tools with which the animal digs from the mud of the bottom the clams and other shellfish on which it feeds, and are formidable weapons enabling it to protect itself and its family and mates, for which the walrus shows remarkable affection and loyalty, from the attacks of the polar bear, the only enemy besides man that it has to fear.

The true seals (*Phocidæ*) have become still further specialized toward a completely aquatic life. Their hind limbs are extended straight behind the body, and take no part in progression, the fore flippers alone enabling them to swim and dive with ease and speed. Their strong, clawlike nails enable them to climb onto ice floes or the shore, to which they resort for rest and sunshine and to bear their young. These are usually only one, or at most two, at a birth, and in some species they have to be carefully taught how to swim, fearing the water. All of the many kinds of seals of this family are confined to the northern hemisphere, and mostly to the arctic region; but the great sea elephant, now almost extinct, lived in the antarctic, with one colony on the coast of southern California. Most seals are gregarious, and some congregate in immense herds on ice floes far from land, but the majority of species stay near shore. Seals feed chiefly on fish, of which they consume enormous quantities; some, however, subsist largely on crustaceans, especially prawns that swarm in the northern seas; also on mollusks, echinoderms, and even occasionally on sea birds.

We are now ready to turn to the land carnivores, which, by the larger opportunity, better food, and varied conditions the land affords, have advanced far beyond their marine cousins. In these more favorable circumstances, and by their struggle for a living against the powers of defense or escape of their intended prey, and the competition of one another, they have become widely diversified in organization and habits, and in some of their representatives have developed the highest intellectual and physical ability in the animal kingdom.

#### BEARS, DOGS, WOLVES, FOXES AND JACKALS

The bears (*Ursidæ*) stand lowest in the scale of rank among the *Carnivora* because they retain more than the others archaic characteristics in their anatomy. The family is singularly uniform—that is, all bears are much alike in their heavy bodies, broad heads, powerful limbs with “plantigrade” feet, resting the whole sole on the ground (whereas most other quadrupeds are “digitigrade,” i. e., standing on their toes), and an extremely short tail, almost invisible in the coat of long hair that clothes their bodies. Distinction into species has been found difficult. An English naturalist once exclaimed that he knew but two in the whole world—the polar bear for one and all the rest for the other. At the other extreme the American systemist, Dr. C. Hart Merriam, announced in 1918 that the American brown and grizzly bears alone were divisible into eighty-eight species and subspecies, based on variations in their skulls! For ordinary readers all the big brown bears of Japan, Asia, Europe, and Canada, inclusive of the grizzlies (of which few now remain) may be regarded as one species; the polar bear, with its



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WOLVES IN WESTERN NORTH AMERICA



BEAR IN A ROCKY MOUNTAIN FOREST

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elongated head and body, and pure, white fur, as another; the small gray "glacier" bear of the St. Elias Alps in Alaska as another; the "blue" one of Tibet, the shaggy, long-lipped, sloth bear of India, and the miniature sun bear of Borneo, as three more; and finally the common yellowish-nosed American black bears, the Andean "spectacled" bear, and the very similar black bears of the Himalayas, as together constituting a seventh species.

All these are as alike in habits, allowing for different surroundings and food supply, as in appearance. Eating everything from nuts, berries, and insects, to fish, ground squirrels, and big game, their dentition comprises not only powerful canines, but molars capable of smashing bones. Bears are too slow and clumsy, however, to do much as big game hunters, save, perhaps, the polar giant in seizing seals, and it is therefore necessity rather than choice that reduces these really formidable beasts to the petty business of nibbling berry bushes, digging up bulbs or the nests of wasps and gophers, and tearing rotten logs to pieces in hope of finding ants and beetle grubs. The most inveterate insect hunter of the tribe is the Indian sloth, or honey bear. Sir Samuel Baker remarks that its favorite delicacy is termites, for which it will scratch a large hole in the hardest soil to the depth of two or three feet. "The claws of the forepaws are three or four inches in length, and are useful implements for digging. It is astonishing to see the result upon soil that would require a pickax to excavate a hole." Having reached the large combs at the bottom of the cavity the bear blows the dust away with a strong puff, and then draws the honey and larvæ out of the comb into its mouth by sucking in its breath.

Nevertheless bears eat a good many young and small animals, and in the neighborhood of farms steal many calves, colts, and pigs. It is an animal to be feared by men when met, although as a rule bears are inclined to run away rather than resist, except when a she-bear feels that her young are in danger. Bears are rather solitary, the males wandering about alone, the females accompanied by cubs often as big as themselves. The young, two as a rule, are born in midwinter in the family den, which may be a rocky cave or the hollow of an old tree, the center of a dense thicket or simply a bed beneath the snow. The cubs at birth are surprisingly small—not larger than rabbits—and are naked, blind, and very slow to develop; hence the mother is extremely solicitous about them, and heedlessly brave in their defense. Bears hibernate only in the coldest regions.

Allied to the bears is the large black and white "coon bear" (*Æluropus*), a rare, vegetable-feeding brute of eastern Tibet, which is a relic of the Pleistocene. Near it in structure is the queer *Ælurus* of the same region, which connects the bears with our raccoons and those other "little brothers of the bear," the kinkajous and coaties of the American tropics.

#### THE DOG FAMILY—WOLVES, FOXES AND JACKALS

Some of my readers may have asked themselves how the order of the families or other groups of mammals is determined—why the edentates follow the marsupials, the Rodentia come next, and so on. The reason is that their ancestors, so far as we know them as fossils, seem to have been related in

a way that indicates such a succession of development in time. It is scarcely more than an indication, however, for although in describing them, or making a list, we must set the animals in a row, naturalists long ago ceased attempting to show that any linear arrangement of that kind represented the reality. The present variety among mammals (as in other classes) is the result of development along different lines from one or more points of beginning.

Throughout a long period in the early part of the Tertiary era there prevailed a class of beasts of prey, some as big as tigers, which, however, were by no means Carnivora, as we now know them, for their teeth in most cases were still of the insectivore type. These were the creodonts, of which I spoke a few pages back. They combined in their structure the features of all the different families of Carnivora, and it was not until there had developed from their stock a single family, Miacidæ, and the rest had died out, that the canine, or carnassial, teeth became prominent in their jaws, and nature found in this the right road to progress. To this anciently extinct family we may trace all the varieties of existing Carnivora. The oldest and most central stock appears to be that of the dog family (Canidæ).

The least of these are the jackals of Africa and Asia, small, active, noisy, reddish and variously marked animals like miniature wolves, which dwell in deserts and open districts, where they hide in dens during the day, and come out at night in search of mice and anything else they can get. They haunt the suburbs of towns, and do great service as scavengers, but also raid farms and villages, killing great numbers of poultry, lambs, and weakly sheep and

goats by methods much like those of our American coyotes.

The coyote is a true wolf; and the wolves are connected with the jackals by a small intermediate species in India. Formerly the coyote ranged eastwardly throughout the prairie east of the Mississippi, but farmers gradually killed it off. On the sparsely settled plains, however, it survives from the Arctic Circle to the tropics in several species, and continues to maintain itself because its natural enemies have been killed off, and because it is extremely clever in dodging new perils. It is far more destructive to the ranchman's chickens, pigs, and lambs than even the big timber wolf, but, on the other hand, benefits the industry by aiding him in exterminating troublesome gophers, prairie dogs and rabbits.

The big gray wolf—the wolf *par excellence*—which our Western men usually call “timber” wolf, to distinguish it from the coyote (the wolf of the plains) is the most widely distributed of all beasts of prey, for despite the various names given it this fierce and capable animal is to be found throughout the northern zones of the globe, from Kamchatka, Japan, and northern India right around to Alaska. Where civilization prevails it has been killed off, yet lingers where mountains give it hiding places even in the oldest settled parts of Europe. In North America wolves abound in all the wilder parts of the West and North, contesting with skill and courage the effort of advancing civilization to get rid of them. This wolf, in its largest examples, such as the often pure white specimens of the Arctic coasts and islands (where it travels as far north as do the caribou and other game), may measure

three and a half feet in length, exclusive of the bushy tail, and may weigh 150 pounds. Its color is typically rusty or yellowish gray above, more or less grizzled, while the underparts are whitish, and the tail is often tipped with black. These hues are paler in northern than in southern specimens, and in warm regions totally black races are known, one of which exists in Florida.

The wolf's mode of life is virtually that of the whole canine family, making allowances for differences in climate and circumstances. Choosing a convenient little cave among the rocks of a mountainside, or, when this is not handy, digging a burrow for themselves, a pair will establish a "den" in early summer, where presently six or eight whelps may be born; but usually only two or three survive babyhood. At this season small game is abundant, and the animals wandering around alone by day as well as by night, pick up a good living, grow fat and lazy, and are little to be feared save by the mothers of fawns or lambs. As the onset of winter fills the forests with snow, cold gales moan through the trees, and the long, dark nights enshroud an almost dead world, this peaceable disposition changes into a hungry ferocity and a force of craft and caution born of the direst need, which at last make the animal formidable to man himself. Yet actual attacks on men are much more rare than stories and traditions would lead one to think. It is at this season, when the rabbits and other small creatures are gone or hidden in hibernation, and large game must be depended on for food, that the wolves form themselves into small companies, or "packs," and assist one another. To this class of animals hunting is truly "the chase," for their method is, having found their quarry (in

which the good nose for a trail and a keen hearing assist them), to keep it in sight and run it down. Having overtaken the quarry, a sideways leap enables them to thrust in the long canine, and drag on it—and the result is death unless the hunted creature is able to turn and fight off its foe with hoofs and horn.

The forests of southern Brazil harbor a long-legged, reddish species called “maned,” which is a true wolf; and South America generally has several kinds of “fox dogs” (genus *Lycalopex*) that sufficiently make up for the absence of true wolves, as do jackals the lack of wolves in Africa and Arabia.

Foxes have long been regarded as constituting a separate genus under their Latin name *Vulpes*, but conservative naturalists now think they belong with the wolves in the genus *Canis* (“a dog”). The type is that of a smaller, more agile and delicate animal than a wolf or jackal, with a broader skull and sharper muzzle, larger ears, a longer, more bushy tail, and usually longer fur. Weaker than its wolfish relatives, though endowed with great swiftness, and used to playing the double rôle of hunter and hunted, its brain has been developed to a high degree to make up for its bodily deficiencies, and shows capacity for further development. Nevertheless the fox is not quite such a marvel of shrewdness as he is reputed to be, and fox hunters in Great Britain—under whose combination of care and chase his education has been more advanced than anywhere else—note much diversity in brain work among them.

Although the North American red fox has a different name from the typical European one it is virtually the same, and shows its skill and adaptability by continuing to live and flourish in the

midst of our civilization, where it practices quite as much sly craft and success in chicken stealing as does "Reynard" on the other side of the ocean. The red fox is to be found all over the continent as far south as Georgia, and where the winters are cold his long and silky fur becomes of marketable value, especially in its darker varieties. The animal has touches of black on the tail and the legs, and this seems liable to affect the whole pelage in the North. Thus some are all black; others are black with every hair tipped with white, and are called "silvers"; others have a blackish band along the spine and across the shoulders. To these the name "cross-foxes" is given. The skins so marked bring high prices, and an extensive industry has arisen in Canada by breeding black and marked foxes in captivity, where pure color strains have been developed, whereas in nature one or more of these melanistic varieties may occur in any litter of normally red parents.

North America has three or more other species of fox, one of which, the gray fox, is common throughout the country east and south of the Appalachian heights, as far north as the lower valley of the Hudson River. It is smaller and grayer than the red fox, is more of a forest-keeping animal, and does not burrow, but makes its nest in the bottom of a decayed tree or stump, or within a hollow log. Living in a climate where small game is abundant the year round, and chicken-stealing comparatively easy, he has not been driven to the straits of getting food in winter to which the northern foxes are driven, and hence has developed less of the ingenuity and cleverness they show. On the high plains of the West dwells a small, active fox, known as the kit

fox, or "swift," which feeds on the ground squirrels and mice of that region, and makes its home in a burrow (often one dug by a prairie dog), where it hibernates in winter. It is now rare and very wary.

Throughout the polar regions right around the globe is found the arctic fox in great numbers, and wandering in summer, at least, to the farthest islands, where its prey consists of lemmings, rabbits, ptarmigan and fish. This is a shy little beast, with blunt nose, short, rounded ears, a very long, bushy tail, and the soles of the feet well shod with hair, giving them a firm and warm grip on the snow and ice over which they leave tiny tracks from Labrador to Siberia. In summer its dress is brown with whitish or drab underparts; but in autumn this is replaced by a coat of long, pure white hair beneath which is an undercoat of fine wool. A small proportion, however, are never either white or dark brown, but are slate gray all the year round. In some rather southerly places the "blues" prevail, forming a local race. Such is the case in Greenland, Iceland, and the Aleutian Islands, where blue foxes are now carefully preserved and cared for in a semi-domestic condition for the sake of their valuable fur. Several small kinds of foxes occur in Asia, and in India one affords some sport with hounds. The prettiest of all are the little sand-colored, big-eared "fennecs" of the deserts of northern Africa and Arabia. No foxes tame well, nor do any of them cross with dogs as wolves and jackals constantly do, and apparently no fox blood has entered into the composition of the domestic dog.

There remain in this ancient and cosmopolitan family a considerable number of animals which from their general appearance we call "dogs."

Among these is the long-bodied, short-legged, primitive "bush dog" of Guiana; the "bakoor" of South Africa; several Oriental species; and the hated "hunting dog" of Africa. The last named is a terror even to a lion. It ranges the country in swift-footed packs, dreaded by every creature of both forest and veldt, and every writer increases its reputation for both strategy and ferocity. This has led to its being killed off, until now it is common only in the remote wilderness. Formerly it was known even in Egypt, and it is the party-colored, prick-eared dog represented on the ancient mural paintings at Beni Hasan and elsewhere.

Of the Asiatic wild dogs the most familiar is that one of India called in the north "buansuah" and in the south "dhole." Like the others it is normally rusty red in color, and makes its lair in rocky jungles, whence, more often by day than by night, it makes its forays usually in packs from which even the leopard and tiger flee—just as in this country half a dozen curs will send a cougar or jaguar up a tree in fright. But it avoids settlements, and does little damage to domestic animals.

This brings us to the consideration of the origin of our domestic dogs, a matter which seems to me more simple than some authors have regarded it. This was doubtless among the very first animals to become attached to the camp or family of primitive man, and in every case, at first, at least, it would be of some local species of wolf, for anatomists agree that no admixture of any blood outside the genus *Canis* is traceable in the dog; and probably would be cherished or tolerated as a reserve supply of food rather than as an aid in hunting. But it is not unreasonable to suppose that when famine came and

the stone ax was raised against the poor animals, those that had proved good watchers, or were the special pets of the women and children, would be the last to be sacrificed and sometimes would be saved altogether. Thus an improving and alterative selection would have begun almost from the start. Moreover, these early camp dogs would become modified by interbreeding and by the influences of captivity; and as their vagabondish owners wandered about would be crossed not only with diverse sorts of tamed dogs, but with the wild stocks of new countries; and this complication would increase as civilization extended. Nevertheless this appears not quite to complete the story. There is a quality which we recognize as "doggy," and as something distinctive. Whence came it? I am of the opinion that it is derived from one or more kinds of canine animals, exterminated by primitive man, which were more "doggy" than wolfish, and which formed in large part the stock of the first domesticated dogs. This supposition is supported by the fact that there have been found remains of a distinct canine species, allied to the Australian dingo, which was domesticated by Neolithic men, and perhaps contributed to existing varieties of the dog. The earliest Egyptian monuments show pictures of large dogs with "lop" ears—denoting one of the most striking differences between dogs and wild wolves or jackals, whose ears are invariably "pricked."

#### THE SOURCE OF COSTLY FURS

A descendant of the Creodonta called *Cynodictis*, which lived in the Eocene, or earliest of the Tertiary periods, is regarded as the forefather of the dog family, but its character is such that it might

as well be said to be the progenitor of the weasel family (*Mustelidæ*), which may thus be suitably considered the nearest relatives of the *Canidæ*. These are the small, but alert, muscular and wide-awake animals whose coats, adapted to the cold regions in which most of them live, furnish us with warm and beautiful furs; hence the *Mustelidæ* may be called the family of "fur bearers." They resemble the dog tribe in the breadth of the skull, and in the dentition, which serves well for the wide variety in their fare; but instead of the long, high-stepping legs of the galloping dogs they have short, strong limbs adapted to creeping, digging, climbing, or swimming. The swimmers are the otters—one marine, the other a denizen of rivers and lakes. The sea otter is peculiar to our northwestern coast, where it used to be very abundant from California to Bering Sea, but is now so rare, on account of the great demand for its unequaled fur, that its pelt is worth several hundred dollars to the fortunate hunter. It is truly pelagic, rarely landing anywhere but on some outer reef or isolated rock, and eating fish, sea urchins, and crabs; and is much larger than the land otter, and with a short, flattened tail instead of the long, tapering one that characterizes the latter. Of the river otters about ten species are recognized, scattered all over the cooler parts of the world, and much alike in their four webbed feet and fish-eating habits. They are lively, playful creatures, and by their wariness, nocturnal habits, and skill in hiding their burrows, made in the bank with an underwater entrance, they are able to persist here and there in the midst of civilization.

Allied to the otters in structure are the badgers and skunks. Of the former, our badger has been killed

off everywhere except in the northwest, where it still digs its deep holes in the ground for its daylight rest and partial hibernation, and finds plentiful food among the gophers, doing the ranchmen more good by destroying these pests than it does harm by its digging. The European badger differs in various ways; and there is an Oriental one, the "stinking" teledu, which illustrates the fetid odor that belongs to all of this family. This disagreeable quality is developed in the skunks into an effective weapon of defense. The food of skunks consists mainly of insects and field mice, and is everywhere so abundant that they find civilization favorable to them rather than otherwise, and remain numerous all over the country in several species, of which the familiar large northern skunk, and the small southern striped one, are best known. The skunks are confined to America, but South Africa has a very similar creature in the zorilla.

We now come to a large number of vigorous, bloodthirsty and cunning little carnivores, the terror of small game, as are the cats of larger animals, which are grouped by their similarity of structure in the "weasel" section of the family (Mustelinæ). Some are mainly terrestrial, others arboreal in habit of life. All have rather long bodies, short legs armed with strong, sharp claws, pointed heads, catlike teeth, and brains equal, if not superior, to any other carnivore. Among the terrestrial species the glutton of Europe and its analogue in Canada, the wolverine, are prominent. The wolverine is a large, shaggy, somewhat clumsy animal that seeks its prey mainly on the ground, but occasionally climbs to a low branch or an overhanging rock whence it may leap upon the backs of a deer or sheep. It displays the

greatest sagacity and persistence in getting a living where life is precarious; and is so clever in robbing the trappers' lures and penetrating his "caches" that the forest people consider it hardly anything else than a devil on four legs, and charge it with deliberate malice. The voracity of its European cousin long ago became the subject of ridiculous traditions, and has given the word "glutton" to the language. Two similar, but smaller, mustelines, the tayra and the grison, inhabit Central and South America. The latter defends itself in the same manner as the skunk.

The weasels, stoats, polecats, minks, and the like form a group distinctly northern, except that one species ranges southward into the Andes. They do their work on the ground, although some are able to climb trees. Slender, lithe, sharp-clawed, secretively colored, and endowed with strength, speed and cleverness, the weasels are the scourge and terror of the ground-keeping animals, and do more than any other class of agents to restrain mice, gophers and similar nuisances. Europe and Siberia have the stoat, the ermine-weasel and the polecat, a domestic form of which is the ferret; and we have in North America several distinct weasels, as the short-tailed and the long-tailed of the East, the bridled weasel of the Pacific Coast, the black-footed ferret of the plains, and the little six-inch "mouse hunter" of the Northwest, which is the smallest carnivore known. All the northern weasels become pure white in winter when they live in a region where the snow lies continuously and the cold is steady; but south of that line they do not change color. The change from the summer brown to the winter white—when they become "ermine"—is

produced by an actual loss of color in the hair; but the spring change back to brown is effected by shedding the old white hair and getting a new brown coat. In the Middle Ages ermine fur was permitted to be worn only by royalty, and later by judges on the bench. A somewhat different, and strictly American, species is the mink. It is somewhat less slender than the weasels, and is semiaquatic in habits, dwelling always near streams, where it feeds on earthworms, frogs, and fishes. Having this kind of food, and being keen-witted and secretive, it has been able to continue to exist in the midst of civilization, and the vast number of its dark pelts that come to the fur market are nearly all got by farmers' boys in traps set near home.

The most valuable of the fur bearers, however, are those that belong to the forests of the North and dwell in trees—the sables, martens, and pekans. The sable is Siberian, the marten is North European, and the pine marten and pekan are North American. The first three are hardly distinguishable, each averaging about eighteen inches in length, exclusive of the long, furry tail, and are brown, somewhat lighter on the underparts, the breast-spot of the Canadian species being orange. The body is long and supple, the legs short and the toes separate, with sharp, long claws, as becomes so expert a tree-climber. The martens exhibit great agility and grace in their movements, and live usually in trees, furnishing with a bed of leaves a hollow in a lofty decaying trunk or sometimes in a rocky crevice. Here the young are brought forth in litters of six or eight early each spring. In winter, however, they descend daily, and hunt rabbits and other prey over the snow. This is particularly true of the big

Canadian pekan, or "fisher" marten, which is the least common of the tribe. These martens fade away as civilization advances toward their forest retreats, and now are to be obtained only in the wildest parts of the Canadian woods; and the effort to tame and breed them in captivity has met with little success.

#### CIVETS, MONGOOSES AND HYENAS

This group of Old World animals represents the product of lines of descent that had their origin very near that of the dogs, as is particularly evident in the history of the hyenas (family Hyænidæ). But between the noble courage and fidelity of the dog and the cowardly brutishness of the hyena lies a great distance in character—as it appears from the human point of view. Of course it will not do to apply our highly elaborated standards to a moral estimate of wild animal behavior, or to use seriously such terms as "cruel," "selfish," and the like, especially in the case of the predatory beasts that work hard for their captures, must kill them the best way they can, and must satisfy their own wants before yielding place to rivals or inferiors; yet we cannot help admiring certain qualities in some of them and disliking others, as if they were inspired by praiseworthy or blameworthy motives. In the character of the hyenas, thus criticised, there is nothing admirable except their extraordinary brute strength. This is shown chiefly in their big heads, where their jaws are filled with teeth of extraordinary size, and are worked by muscles that enable them to crunch the leg bones of an ox, or indent and bend thick iron, of which amazing examples are given by Selous, Neuman and other African sportsmen.

Otherwise they are the meanest of brutes, hated and despised by every man and beast in the countries (Africa and southern Asia) that they afflict.

Related to them, but very different in every way are the many species of ichneumons and civets (family Viverridæ) of the same parts of the world. The ichneumons, or mongooses, are small, dark-colored, unspotted animals, varying in size from that of a weasel to the bigness of a house cat, with compact bodies and pointed muzzles. They are active, bold and predacious, living on small game of every sort, and making their homes in holes in the ground. They are noted for their animosity to reptiles, and in ancient Egypt were protected as "sacred" because they killed asps and hunted for and ate crocodiles' eggs. The old term "ichneumon" has disappeared, however, in favor of the term "mongoose," which is the name of the East Indian species famous for snake killing. It is able, by its astonishing quickness, to spring upon and kill a cobra, even when that deadly snake is prepared to strike at its little foe. Mongooses were colonized in Jamaica and other West Indian islands years ago to destroy the rats that were a plague in the sugar plantations; but they presently turned their attention to the poultry as easier game, and became a greater nuisance than the rats. These fierce little snake killers constitute the "herpestine" section of the family.

The "viverrine" section contains the civets, which have elongated bodies, terrierlike heads, small, round, five-toed feet with imperfectly sheathed claws, long, often bushy tails, and coats of rough dark-colored hair marked with blackish stripes, bars, or squarish blotches. The species are numerous and varied, those of central Africa, called



BAT WITH YOUNG BAT IN EACH POUCH, FOUND HANGING TO A TELEGRAPH WIRE, NEAR LINCOLN,  
NEBRASKA

Photo, Keystone View Co.



Photo, Ewing Galloway

BLACK SPIDER MONKEY



Photo, Elwin R. Sanborn, New York Zoological Society

ATTRACTIVE RUFFED LEMUR

“genets,” resembling weasels. They include the linsangs of the East Indies, with soft, fawn-colored fur; several East Indian species inhabiting trees and going by the name of “tree cats” and “toddy cats,” one of which is domesticated as a mouser and pretty pet by the natives; and the black binturong of the Orient, which is the only animal of the Old World, not a marsupial, that has a prehensile tail.

The distinctive peculiarity of the true civet cats is the possession of a pair of open pouches in the groin holding an oily substance having an intense musky odor and known as “civet.” This is present in the five Oriental species, but is most copious in the civet cat of northern Africa, which on this account is kept captive and occasionally relieved, by the aid of a small spoon, of its civet for which perfumers will pay a high price.

Madagascar possesses a remarkable animal in the foussa, or fossane, which is nearly the size of our puma, has a weasellike head and a very long tail, and is a fierce nocturnal marauder. It is classed with the Viverridæ, but stands intermediate between them and the cats.

## CHAPTER XXXIV

### BEASTS OF PREY—*Continued*

IN the cats (family Felidæ) we come to the most recent and advanced development of the carnivorous type, by straight descent from the Eocene Miacidæ. Their cardinal characteristics are found in their round heads and short muzzles; their teeth fitted for cutting rather than chewing, with sharp and slender canines very prominent; their sheathed claws; and their powerful activity. Although the civets and the foussa have retractile claws they do not show the perfection exhibited in this feature in the cat family. Here the final bone of every toe (the terminal phalange) is so hinged upon the one next behind it that ordinarily it stands upright, held there by an elastic ligament, with the sharp, curved claw hidden in a sheath of skin and thus kept from touching the ground and so becoming blunted; for in the cat's method of work sharp claws are needed to hold the prey on which it has leaped until its teeth can come into play. When this seizing leap is made a tendon running along the underside of the toe is retracted, pulling down the claw and causing it to pierce and hold the body of the victim. This is the explanation of Puss's familiar scratching ability, and accounts for the fact that while dogs, developing long legs for their style of attack, chase and finally seize their prey with their big, strong canines, cats steal upon it or more often lie in ambush and

pounce on it, using their slender canines mainly as piercers. The cats do their hunting mostly alone, and are therefore largely at the mercy of wolves, etc., who go in packs; and herein lies the origin of the fear and hate with which cats regard all dogs.

The cats are a very uniform group, all the many species belonging to the single genus *Felis*, except the few lynxes and the cheetah. No better example of the race can be found than our "fireside sphinx." She is a direct descendant of the "Caffre," or "Libyan" cat, a native of northeastern Africa, and especially of Egypt, where she still runs wild. Reddish sandy in color, with faint, broken, darker bars across the body, limbs, and tail, and narrow vertical lines on the face, excellent copies of this original of all the domestic cats of the western world, at least, may often be seen in our houses. This likeness is supported by the evidence of history and archæology—the skeletons of Egyptian cat mummies, and bones associated with the dawn of history. In regard to the present, however, some deduction must be made. In all parts of the world one or another of the smaller wildcats of the country have been kept as pets in native houses; and wherever the people have been far enough advanced to raise and store grain, they have cultivated a cat or some other animal to free their granaries from thieving mice. It was for this purpose, no doubt, that the cats of Egypt were first tamed; and then, to make the people prudently keep them and care for them, the priests invented a beneficent and cheerful cat goddess, who, naturally, was said to walk abroad mostly by moonlight. When the tamed Egyptian cats reached Europe with the early Phœnician colonists and traders they would certainly soon meet and

interbreed with the native stock; and to such crossing is probably due the banded or "tabby" cats. On the other hand, brindled cats were formerly unknown in eastern Asia, whose spotted or foxy house cats were derived from other and local sources. Since intercourse between Europe and the Orient became frequent, more or less mixture has occurred; although one very distinct Eastern breed persists—the long-furred Persian or Angora cats, a race probably derived prehistorically from the manul, of Turkestan.

The differences between members of this genus *Felis*, all of which seem able to interbreed, when similar in size, are chiefly of size and coat. Their prey and hunting methods are substantially alike everywhere, and in domestication cats are slow to vary from the wild type in any respect except in color—a result of their mixed ancestry. Puss remains a savage in a civilized coat, and, accepting condescendingly the novel comforts offered her, refuses to forsake her own forest gods for the fireside shrines of her tempters.

The word "wildcat" is naturally used for any small feline, but strictly belongs to the yellowish, tabby-marked, forest cat (*F. catus*) of Europe and Siberia, now becoming rare. Closely allied to it is the manul, of the central Asian steppes, where the long fur that envelopes it (as preserved in our domestic Persian beauties) is required by the awful cold of those lofty plains. Several other small cats inhabit the desert parts of southern Asia, which abound in rodents; and the long-legged, powerful, fawn-colored caracal ranges, nowhere numerous, from India and Mesopotamia around to Arabia and South Africa. Africa has several other cats of the

open country, the best known of which is the swift-running, handsome serval, which is an expert tree climber. Southeastern Asia has three or four beautifully marked forest cats, and four of great size—three leopards and the tiger.

The typical leopard is distributed from China and Borneo westward to southern Arabia and all over Africa, except in deserts and cold mountains; but the ounce, which may be regarded as a variety of it, inhabits the Himalayas, staying near the borders of the snow line for the most part, and another beautiful variety, the clouded leopard, frequents the forests of the median slopes of that vast range. The ground color of the leopard is yellowish brown, of varying intensity, and is thickly covered with rosettes of black spots inclosing a clear area, with the breast and belly white. The favorite haunts of leopards are rocky, brushy hills with holes suitable for a den, where they may watch the surrounding country, and at sunset descend with astonishing celerity and stealth to cut off any straggling animal returning to the village at nightfall. They prey boldly on the small Hindu cattle and ponies, but more habitually on the sheep, goats, and dogs, and now and then (but rarely) turn man-eaters.

The leopard cannot overcome, ordinarily, animals as large as the lion and tiger slay, but everything of lesser size is acceptable, down to robbing birds' nests and clawing grubs out of rotten wood. It is somewhat smaller than our cougar, a male in good condition weighing about 125 pounds.

The tiger—for there is only one, in spite of circus advertisements of a "royal Bengal" as something different—is purely Asiatic, the species ranging from the Caucasus and the mountains of Ararat to



TIGERS  
(*Felis tigris*)

the East Indies (Sumatra and Java), and northward to central Siberia and Sakhalin. It is to be found throughout all India, but does not occur in Ceylon.

Speaking of the tiger always brings to mind that other great cat, the lion. These powerful marauders dispute the title of "king of beasts." Their respective realms overlap but little. The lion, like the other big cats, is a relic of a diminishing race and kingdom. In the early Stone Age the "cave" lion (virtually the same as the present *Felis leo*) roamed throughout the southern half of Europe, and its final extermination north of the Mediterranean was doubtless accomplished by prehistoric men. Afghanistan, Beluchistan and northern Persia were rid of them long ago. A century ago lions were more or less prevalent in northwestern India, but now none remain save a few in the Gheer, a wooded hilly tract of Kattiawar. In Persia they survive only in Farsistan, where marshes afford shelter, and the hosts of pigs feeding on the acorns of the oak forests furnish subsistence. But they were long ago exterminated from all Asia Minor, Arabia, Egypt, and Algeria. From Abyssinia, and the southern Sahara southward to the Orange River, lions still exist except in the most populous districts, and in some places are very numerous. This range of territory shows that, unlike the forest-loving tiger, the lion is an inhabitant of open, bushy country, finding its game in the herds of antelopes, zebras, and similar plains-running animals rather than in the jungle fauna to which the tiger is confined; also that the tiger is inured to a far colder climate. This difference in habitat and hunting requirements accounts, in the minds of those who pay much attention to adaptive (or "protective") coloration, for the dif-

ference in their dress, for the tiger is said to become almost invisible in its yellow coat and vertical black stripes amid the flickering shadows of the wood, or when creeping through the long Indian grass, while the unmarked, grayish yellow, or sand tint, of the lion is equally unnoticeable on the desert or on the sere veldt of its East African hunting grounds. The great mane of the male lion—but some never acquire this ornament, or only scantily—and his greater height at the shoulder give him a majestic mien.

A lion of large size measures about nine and a half feet from the nose to the tip of the tail, which is about three feet long; stands three and a half feet high at the shoulders; and weighs about five hundred pounds. Most specimens, however, fall far short of these figures; and the largest examples have come from South Africa. The dimensions and weight of tigers average just about the same, the extreme examples on record having no doubt been measured along the curves of the body instead of in a straight line between the two terminal points, nose and tip of tail, as is the proper method. The literature relating to these two royal and puissant beasts is immense in its extent, and the best of it is that written by the hunter-naturalists who during the past century have studied and fought them in their native wilds.

The western hemisphere has a series of native cats which, although not equal in size and strength to the lion and tiger, are hardly less formidable in view of the game they hunt. The biggest is the jaguar, which is found from western Texas to northern Argentina. It is about the size of the leopard, but has a bulkier body, bigger head, shorter and



LION  
(Felis leo)

more massive limbs, and shorter tail; hence, while less active and supple, it is perhaps more powerful than the leopard, and certainly is stronger than the puma. The ground color varies from the yellowish gray seen in arid Paraguay to almost red in the steaming equatorial swamps, while in the lower Orinoco Valley deep brown and black ones are common; but there is only one species. The coat is everywhere spotted with black, not in the leopard's hollow rosettes, but forming larger, irregular groups, each inclosing a black central spot.

This is the "tigre" of the American tropics, and indeed, is so called wherever Spanish is spoken. It hunts the largest game of its country, especially tapirs and deer; and wherever domestic animals are reared it becomes a destructive pest. For the most part, however, these cats subsist on capybaras and other rodents; and in Mexico on pecaries, striking down stragglers and then hastening up a tree out of the way of the furious herd of these sharp-toothed pigs brought together by the squealing of the first victim. Rarely found away from water, which seems as necessary to it as to the tiger, it is not surprising to find that in such places as the reedy borders of the La Plata fish form its main diet, snatched from the water by the paw. On the Amazon it feeds largely on turtles and their eggs. It attacks the manatee in its own element, and has been seen "dragging out of the water this bulky animal, weighing as much as an ox." Even the crocodile and cayman are regularly preyed upon. Its fondness for monkeys is also well known, and it is hated and reviled by them with the same fury as leads the East Indian apes to hurl sticks and bad language at the tiger.

The "cougar," as Buffon named it, the "puma" of the Peruvians, "panther" and "mountain lion," as it is known in the United States, is another big American cat familiar to woodsmen from New England, Minnesota, and northern British Columbia southward to Patagonia; and everywhere it is so precisely uniform that the most hair-splitting systemists have been unable to subdivide its species (*Felis concolor*) into local varieties. Its upper parts vary from foxy red to a dull blue, this difference in color having no reference to age, season or locality. The underparts are white; and there are no spots anywhere except that the lips and outer rim of the ear are black, and a patch of white marks each side of the muzzle. The panther was much dreaded by the early settlers of the Eastern States and by the frontiersmen settling the Mississippi Valley, who were more alarmed by its doleful screams as it wandered about in the night, than by any history of harm, for it avoided men with a greater fear than their own; nevertheless, it became a nuisance by its raids on the farmer's live stock and he killed it off, so that now pumas are to be met with only in the forested and swampy fastnesses of some of the Gulf States and in the Far West. There they still do great damage to the young animals on ranches, especially where horses are plentiful on the range. This is equally true of South America. Nowhere, however, is the puma feared by mankind as is the jaguar; on the contrary, remarkable stories are recorded, and constantly being verified by experience, not only of the cowardice of the animal, but of its apparent desire to make friends with humanity, following lonely persons without harming them, apparently merely in satisfaction of an innocent

curiosity. It is hunted usually with dogs, to escape which it will climb into a tree, and once there remain to be shot rather than come down to fight, even when the hunters are close up.

Tropical America is the home of several smaller cats, some of which among the spotted ones are probably only varieties of the ocelot. This highly variable but always beautiful creature is about two and a half feet long in body, rather long in the legs, is an expert tree-climber, and is abundant from Oklahoma southward into the Brazilian forest, but has a different name in every country. It is grayish, thickly marked with fawn-colored, black-edged, oval patches and stripes in endless variety; and its fur is one of the most marketable in the country. On the prairies and plains of the open country south of Brazil the pampas cat, or "pajero," is common. It is of robust form, with long hair, very plain in its grayish tint on the back, but beautifully spotted and striped on the belly and legs. It is a ground-runner, preying on rodents and birds. Brazil has in its forests a notable cat of medium size called "jaguarundi," with a noticeably slender form, short legs and a tail nearly as long as its body. It is dark gray in hue and entirely unspotted. This may, on further study, turn out to be only a variety of the "eyra," another cat of the tropics, sometimes met with as far north as the Rio Grande Valley, which looks in its unspotted chestnut coat more like a huge weasel than a cat. It is a graceful and nimble climber, and lives on prey caught in trees.

Our common "bobcat," the wildcat best known to most readers, is a lynx—one might say *the* lynx, since in spite of the wide variety that specimens show between those of Quebec and those of Texas,

for example, all seem to be one species, which is only locally different from the lynx of the Old World. But Spain appears to possess a distinct species in the pardine lynx. Lynxes differ from the typical cats (*Felis*) in having only two instead of three pre-molar teeth, but most notably in their heavy bodies, stout limbs, big and powerful feet, very short, thick tails, and the tufts of hair on the tips of the ears. The big Canadian lynxes are clothed in coats of long grizzled hair, valuable in the fur market and suited to the freezing winters of their home, where their fare during the cold months is restricted almost entirely to hares; but in the United States, and especially toward the south, these cats are much smaller, have thin coats and show reddish and yellowish tints with much spottings. They have survived the presence of civilization wherever rough hills or swampy forests give them a refuge, and they prey on mice, rabbits, birds, and poultry.

A single cat remains to be mentioned, the curious cheetah, or hunting leopard, which is known all over southern Asia, and Africa, and in India and Persia is trained to hunt antelopes. It is somewhat less in size of body than the leopard, but stands on long legs, and in color is yellowish, with many obscure blackish spots. Its great peculiarity, however, is the fact that its claws are not retractile, like those of the true cats, or only partly so; and that it chases its prey with great speed and in a doglike manner, although lacking the dog's persistence and endurance. This mingling of characteristics makes it hard to classify, and it perhaps should have led, instead of closed, the chapter on the cat family.

## CHAPTER XXXV

### INSECTIVORA—HEDGEHOGS, MOLES AND SHREWS

**A**GAIN we have to deal with the scattered and feeble relics of a once important race; but that was long ago, even as geologists use the word long, for the order of insectivores (Insectivora) may be traced backward to the very earliest, hardly identifiable, fossil remains of mammalian pioneers in a reptilian world. These are known mainly by their dentition, which in this order is characterized by weak canines, small sharp incisors, and all the back teeth small, with many points and sharp edges designed for cutting through the shards of insects, shells of eggs, snail shells and the like, rather than for chewing. They had become, even in the Eocene period, a numerous and varied group, including arboreal, terrestrial, and aquatic types, some of considerable size, besides many minute forms comparable to the moles and shrews of the present day, and very likely ancestral to them. At the beginning of the Tertiary, they are indistinguishable from the earlier of the creodonts, but these rapidly developed into powerful beasts, while the insectivores retained more nearly their ancient ways, and in the later Tertiary diminished rapidly in numbers and variety. To-day only a few survivors are left, protected from their enemies by armor, as in the case of the hedgehogs; by a subterranean mode of life, as the moles;

by their agility, minute size, and unpleasant odor and taste, as are the shrews; or, finally, by their exile in some remote corner of the world, where enemies are few. Thus we find remnants of families so widely separated as Madagascar and Cuba—the same disintegration that has overtaken many another ancient and decadent tribe; and their organization is so generalized that systemists find it difficult to place them in any serial arrangement with other orders; the big Malayan kaguan, for instance, which lives in trees and looks and behaves like a flying squirrel, was long classed with the lemurs.

Oldest of the existing insectivores, and nearest the original type, is the hedgehog of Europe, which, when rolled up, presents to its enemy a living chestnut bur of stiff spines hardly bigger than a baseball. All day it lies curled up asleep in an underground nest (where in winter it hibernates), and wanders about at night hunting for insects, worms, snails, slugs and the like, and savagely attacking and killing every viper it comes across—a valuable little animal, preserved by every intelligent gardener. Next to it are the lively little “tupaia,” or tree shrews of the East, and the queer, long-nosed, kangaroo-shaped jumping shrews of the deserts. A rarer oddity is the river shrew of West Africa, looking and acting like a miniature muskrat. Then there are the “almiquis” of Cuba and Haiti, which suggest small, ground-traveling opossums, whose nearest relatives are the spiny “tenrecs” of Madagascar.

More familiar to us are the moles and shrews of northern countries. Moles are chiefly remarkable for the adaptation of their frames to the requirements of an underground existence, in which they must travel and seek their food, and not merely

make their nightly home in burrows. This has brought about an alteration of the forelimbs into digging tools of really gigantic power when we consider the size of the animal, and a strength of shoulders that enables them to bore their way through loose soil without shoveling it out, save at long intervals. Everybody knows the upheaved ridges that mark their paths on the lawn as they move here and there beneath the grass roots in search of grubs and earthworms. One of our common species, preferring wet meadows to the uplands, is the star-nosed mole, whose muzzle is encircled by pink tentacles, very sensitive, which give it its name.

Highest in rank among insectivores, though least in size, are the shrews, one of which, our Cooper's shrew, is the smallest of all mammals. They are mouselike in appearance, but with long, flexible, much bewhiskered snouts, and are ceaselessly active, wandering about underneath leaves, old grass, and logs, and boring their way into loose loam or the punky wood of decayed stumps, in search of earthworms, grubs, beetles, slugs, and similar prey, including young mice and the fledglings of ground-nesting birds, and varying this fare by bites from soft-shelled beechnuts, tuberous roots, etc. They are quick of hearing, bold, pugnacious, and fierce, often killing and eating other shrews; difficult to keep alive in captivity, utterly untamable, and easily frightened to death.



Photos, Elwin R. Sanborn, New York Zoological Society  
MANDRILL, MOUTH OPEN TO SNARL



GORILLA, SOMEWHAT THOUGHTFUL



CHIMPANZEES IMITATING SOME OF THE WAYS OF MAN

Photo, Elwin R. Sanborn, New York Zoological Society

## CHAPTER XXXVI

### THE BATS—WING-HANDED MAMMALS

**N**EXT in advance of the Insectivora stands the order Chiroptera ("hand-wing"), which is the tribe of bats, divisible into two suborders—the large, diurnal fruit bats, and the small, nocturnal insect-catching bats and the vampires. No fossil remains bridging the gap between these two orders has been discovered, nor can anyone yet explain the steps in the acquirement of the bats' power of flight.

Bats are simply flying mammals, necessarily small, with the bones of the forelimbs light, hollow, and greatly elongated, the middle finger in some cases exceeding the total length of the body. These lengthened digits support between themselves and the hinder limbs a membrane that opens and closes much like an umbrella. This wing membrane consists of a double layer of skin, one continuous with the hide of the back, the other with that of the abdomen, fused together. The surface of the wing is covered with microscopically minute hairs. To these hairs and the bulbous underlying "end organs" are attributed the bat's exalted sense of touch. The expanse of these leathery wings is far greater than that of most birds relatively to the size of the body, but the muscles are weaker; and the exterior thumb, with its strong claw, by means of which bats scramble about rocks and buildings, recalls the similar organ in archæopteryx. The hind limbs are

small, while the knee bends backward because of the outward twist of the limb. This makes the foot almost useless for walking, but fits it, with its peculiarly strengthened ankle, to be extended straight backward and serve as a means of hanging the body head downwards—the bat's ordinary attitude in rest or sleep.

Bats usually produce two young at a birth, and the mother carries them about with her, they clinging to her breast, where she keeps them warm by folding them within her wings when they and she are hanging to the branch of a tree. Nothing is made in the way of a nest.

The fruit-eating bats (division Megachiroptera) are distributed in some seventy species from East Africa to the East Indies, Japan, Australia, and Polynesia. They vary in size from an ounce in weight to some as large as big squirrels, and in form from the grotesque "hammerhead" of Africa to the many rust-red East Indian species that come naturally by their name of "flying foxes," and approach foxes in size. These bats feed on all sweet fruits, and in some regions, as Java, no delicate fruit can be raised unless the tree is protected by nets. It is at night that they make their forays, sleeping during the day in great companies among the branches of some chosen tree.

Where a fig tree attracts a crowd of them, we are told by Eastern writers, the roughest fighting begins over coveted plunder, each one screaming, clawing, biting, and struggling to seize something and get away to a secure retreat to enjoy it. No doubt these squabbles are rendered more violent by the dissipated habits in which the bats indulge during their nocturnal expeditions, for, according to Dr. Francis

Day and other observers, "they often pass the night drinking the toddy from the chatties in the coconut trees, which results either in their returning home in the early morning in a state of extreme and riotous intoxication, or in being found the next day at the foot of the trees, sleeping off the effects of their midnight debauch."

The second division (*Microchiroptera*) contains the carnivorous bats, which include five families, two of which, the nose-leafed and the desert bats, belong to the warmer parts of the Old World, and the others are tropical (*Emballonuridæ*, and *Phyllostomidæ*), or have an almost cosmopolitan range (*Vespertilionidæ*). In general the bats of this division are night flyers, and retire during the day to caves, hollow trees, and dark places in old buildings. Such haunts contain great deposits of black guano, which in many places is gathered as a most valuable fertilizer. The rock tombs and temples of Egypt and the East are haunted by thousands of these tenants, and are occupied the year through; but in cool countries the bats migrate or may go into a partial hibernation. The food of most of them, and especially of the *Vespertilionidæ*, to which all those of the United States and western Europe belong, is exclusively insects, caught on the wing in the twilight hours or in moonlight; and the service thus done to mankind is of much importance. In the tropics, however, several species, especially of the family *Phyllostomidæ*, feed largely on fruit, being provided with long, brush-tipped tongues with which they scrape out the soft interior of the banana and similar fruits. Two species of this family are the famous "vampires" of the American tropics. The name recalls the superstition rife in

Europe in the Middle Ages as to blood-exhausting fiends which were fabled to lull their victims into unconsciousness by the slow flapping of their wings, and then deprive them of life. The foremost of these vampires is a small reddish species (*Desmodus rufus*), whose front teeth are like keen daggers, while the cheek teeth have disappeared, having nothing to do, since the animal subsists wholly on a liquid diet.

## CHAPTER XXXVII

### MAN'S HUMBLE COUSINS

**W**E have now arrived at the highest division of the Mammalia, the order Primates, a term here signifying "first" in rank of importance by reason of the possession of a structure and faculties superior, as a whole, to any other class. It includes the lemurs, the monkeys and baboons, the anthropoid apes, and mankind. Man's undeniable superiority to all the others is intellectual rather than physical (for in this or that particular he may be inferior in ability to many of the lower animals), and is much less apparent in primitive men than in those highly civilized.

All primates have five fingers or toes, each covered at the tip by a flat nail; and in most cases the thumb or great toe, or both, are "opposable"—that is, may be bent around opposite the other digits so as to form a grasping organ. The higher the primate in the scale of organization the more perfectly are its forelimbs and hands adapted to seizing and handling objects, and its hind limbs to supporting and moving the body; and the whole sole of the foot rests upon the ground. These and other characteristics fit the primates for life in trees, where nearly all spend their time. The number of young, as a rule, is no more than two annually, and they are born in a helpless condition, hence they must for a period be nursed and be carried about by the mother.

The food consists almost wholly of fruit and other soft or easily digested vegetable materials, insects and eggs, and the teeth are of nearly even size.

#### LEMURS, GALAGOS AND AYE-AYES

The lemurs, or half-apes, are a large group of small tree-dwelling animals that paleontology shows were in early Tertiary times much more closely connected with monkeys than they are now; and it also shows that in a former age their ancestors were scattered all over the temperate parts of the globe; this assists us to account for the strange distribution of the remnants that now live—a part of them in the Malayan archipelago and a part in central Africa and Madagascar, in which island, indeed, lemurs abound more than elsewhere, owing largely, no doubt, to the scarcity of enemies. They differ from monkeys in having elongated jaws, giving a foxlike aspect to the face, in the woolliness of the coat (as a rule), and in their nocturnal habits and weird cries that have been the source of many curious superstitions and a reverence that no monkey ever inspired.

The most specialized of the group is a wan little Malayan creature about the size of a small rat, with a long tail, long hind legs, and toes ending in pads that enable the tarsier, or "marmoset," as it is called, to climb the smoothest bamboo. Its eyes are so big they seem to leave no room for cheeks. Even more curious is the aye-aye of Madagascar, which resembles a small squirrel with a terrier's face; its hind feet are like a monkey's hand, and its forefeet are composed of very long naked fingers armed with sharp claws useful in pulling bugs and grubs out of crevices in bark, or the pulp out of fruits.

The typical lemurs have rounded heads, doglike muzzles, and a soft, thick, woolly fur of various colors that is usually extended to form a long, bushy tail; and the largest of them, the "babakoto" of eastern Africa, is as big as a cat, and makes the woods ring at night with doleful howls. They hide in holes in trees or in leafy nests during the day, and at night wander about in trees, or on the rocks of the mountains they frequent, in search of insects and sleeping birds and their eggs, etc. All the lemurs proper, and their relatives, the endrinas, belong to Madagascar. On the mainland a somewhat different race, the galagos, abound throughout central Africa, and are renowned for their leaping powers, general activity, and willingness to eat anything they can catch or find ripe in the way of sweet fruit. They are interesting as pets. The "slow lemurs" of the Malayan islands, on the other hand, are noted for their sleepiness, moving about the trees with such slothlike sluggishness and caution that it is a wonder they ever capture enough food to keep alive. They are regarded with great fear by the natives, not because they are more harmful than the other lemurs, which are also dreaded, but because of strange supernatural powers attributed to them. These ideas are older than our science, for the name, *Lemures*, given them means "ghosts."

A remarkable thing about the Primates is that they show, even in man himself, many structural traits recalling the anatomy of that remote source of so many mammalian branches, the creodonts; and the lemurs seem to stand between the Insectivora and the Primates, and are certainly the most ancient part of the latter order, with many affinities to the former. In a similar way they are connected

with the monkeys and apes by the marmosets. A very suggestive fact is that the scattered distribution of modern lemurs much resembles that of the comparatively few existing insectivores, especially as to Madagascar, which was united with the continent of Africa during the earlier half of the Tertiary era.

#### MARMOSETS, MONKEYS AND BABOONS

The marmosets, or "teetees" (titis), are a small family (Hapalidæ) of little, arboreal, monkeylike creatures much enjoyed as pets in the American tropics, but rarely able to endure our northern winters even when protected most carefully from the cold. They look and act much like pretty squirrels, have long, but not prehensile tails, and some of them, as the "tamarins," have long silky manes. They possess several lemurlike features, and, as has been said, are a connecting link between the lemurs and the monkeys proper.

All the monkeys of the world are members of one or the other of two families only—the Cebidæ, all American, and the Cercopithidæ, confined to the Old World. They differ in several structural particulars, among others in the number of teeth, and in the matter of bare spots of naked skin on the buttocks (not seen in the Cebidæ), in the prehensility of the tail, exclusively American, etc.; but the most striking difference between the two groups is found in the nostrils. In the Old World monkeys and apes (Catarrhines) the nostrils look downward and are close together; in American monkeys (Platyrrhines) they are widely separated and look outward. This absolute distinction between the Primates of the two hemispheres has existed as far back as the race can

be traced by paleontologists, who have discovered no intermediate forms.

The American monkeys, or "sons of Cebidæ," as Dr. Cope once expressed it, comprise the capuchins (*Cebus*), which may be taken as the representative genus, the woolly monkeys (*Lagothrix*), the spider monkeys (*Ateles* and *Eriodes*), the howlers (*Myctetes*), the sakis (*Pithecia* and *Brachyurus*), the night monkeys or *durukulis* (*Nyctipithecus*) and the squirrel monkeys or *saimiris* (*Chrysothrix* and *Callithrix*). All are small, the largest having a body no more than twenty inches in length, and are hairy or woolly, without any naked callosities. Their headquarters are in the great forests of equatorial South America, which is the exclusive home of many species, some of which are restricted to narrow areas, the great rivers often acting as impassable boundaries. No monkeys ascend high in the Andes, or reach the West Coast; and none is found far south of the forests of Brazil or north of south-central Mexico.

They are adapted to a life in trees, and most of them are aided in security in hurrying about their precarious paths through the tree tops by the fact that the tip of the tail, naked on the underside, will almost automatically curl around a branch, gripping it so firmly that the animal may hang by this grasp alone, leaving all four hands and feet free for other service. Their agility, especially in the smaller long-legged spider monkeys, is proverbial; but one must not believe the old wonder tales of "living bridges" and the like. Best known are the capuchins, which furnish most of the pets and organ grinders' slaves seen in the United States; and their manner of life is substantially

that of the whole tribe, with such exceptions as that of the big-eyed durukulis, which are strictly nocturnal in habit, and the big reddish "howlers" that make the forest ring with lionlike roars at certain times, giving the impression that a large company are howling in chorus when it is only a solitary old male that makes all the noise. The capuchins, like most other species, go about in small, orderly bands, led by the oldest male, and remain most of the time in very tall trees. Bates, in his "Naturalist on the Amazons," describes how, when the foremost of a flock of monkeys reaches the outermost branch of a tall tree, he springs forth into the air without a moment's hesitation, and alights on the dome of yielding foliage belonging to the neighboring tree, maybe fifty feet beneath, all the rest following his example.

The Old World monkeys are, as a family, of higher grade, larger size, and greater historical interest than those of America. Fossil remains show that the tribe is an old one, and was once able to range all over Europe; now the few half-captive and altogether mischievous apes on the rock of Gibraltar represent all that remain of a species once numerous even in northern France, and so recently as the Pleistocene. This ape is a macaque (*Macacus*), a genus that otherwise is purely Asiatic and contains some of the most celebrated of the monkeys. Thus, the suitably named pig-tailed macaque of the Far East is trained, in Sumatra and Borneo, to climb the coconut palms and select and throw down ripe nuts—the most really useful thing to the credit of monkeys; the Japanese species is the one that is so much used in the decorative designs of that artistic people; and the best known of all is the com-

mon Bengal or rhesus monkey, which is revered by some sects of Hindus, and is treated with tolerance or made a pet of, or an aid to jugglers, throughout India. Several other macaques are common pets and servants in the East. The macaques go about in flocks, and often come to the ground. All have the habit of cramming food into their cheek pouches for mastication at leisure. The majority of the species are very docile when young.

Closely related to the macaques are the mangabeys, or white-eyelidded monkeys of West Africa, and the central African genus *Cercopithecus*, which includes many small-sized, handsome, tree-living kinds, of which the most widely known is the diana monkey, whose long fringe of white hair hanging from its neck and chest is in much demand in the fur market. Even nearer relatives are those interesting but often repulsive creatures, the baboons, between which and macaques stands the doglike, stub-tailed, ground-keeping black ape of Celebes. This eastern instance of an otherwise African group, like the single western macaque, indicates, what fossil remains prove, that both genera were once far more wide-ranging than at present.

The African baboons, of which there are about a dozen species, present striking peculiarities in appearance, and all are much alike. In size they vary from the bigness of a spaniel to that of a mastiff, and a comparison with dogs is apt, for these apes go about habitually on all fours, their limbs are stout and of about equal length, and their heads and muzzles are canine; hence the ancient name *cynocephali*, dog-headed. In some, as the mandrill, the naked nose is swollen at the sides like a hog's snout, thrown into ridges and colored black, pale pink, or

blue and purple; while the great callosities on the stern are of the same or contrasted colors. The fur is blackish, or yellowish or greenish, grizzled by the fact that every hair is ringed with various colors; or the coat may be party-colored. They go in bands, sometimes exceeding one hundred individuals of all ages, and choose for their lairs cliffs and rocky ridges full of crevices and thickets, such as the extraordinary Black Rocks of Angola, where the yellow baboon dwells in thousands, and subsists mainly on lichens. In such places they are safe against any enemies except leopards (which the old males are said to be able to vanquish) and the larger serpents or birds of prey; and these can make away only with the young now and then. Dogs dare not attack full-sized baboons, which have been seen again and again going fearlessly to the aid of some little one that dogs have tried to seize. Their sense of smell is amazingly keen, especially for hidden water springs in the desert. It is recorded that the Bushmen of the Kalahari plains used to train captives to help them search for water when famine was impending; and undoubtedly the observation of what roots, etc., these animals were accustomed to eat taught the earliest human venturers into these regions what might be used there in the way of food. Baboons also eat lizards and the like, and are fond of honey and certain gums. With these habits it is not surprising that they are everywhere exceedingly harmful to plantations, tearing up or trampling down more than they can consume, and destroying a field in a night. Some of these baboons are as tamable and teachable as other monkeys, but they grow unruly and ferocious as they become old. They were tamed and trained in ancient Egypt, where

a religious sect held the shaggy Arabian species (*Cynocephalus hamadryas*) to be sacred to Thoth, whose statues are a human figure with a baboon's head.

#### GIBBON, CHIMPANZEE, GORILLA, ORANG-UTAN

This brings us to the anthropoid ("manlike") apes of the family Simiidae, which differ from the inferior apes that have been described in fewer particulars than their size and appearance might suggest. Thoroughly arboreal for the most part, when these apes come to the ground they progress in a semi-erect fashion. Moreover when they put their hands upon the ground to aid in walking, they do not rest their weight, as do the lower apes, upon the flat of the hand, but upon the back of the fingers. None of the anthropoids has a tail.

The gibbons are an Indo-Malayan group of monkeylike anthropoids with small, long-nosed faces, and arms so long that when the gibbon stands erect the fingers touch the ground. By means of these long arms they swing themselves through the tree tops with astonishing speed, and are adept at climbing and leaping about the mountain slopes that are their favorite resorts. All the gibbons are noted for their far-carrying voices, and often a band will utter weird howls in chorus answered by another band, so that the forest is filled with indescribable noises. The largest is the jet black, Sumatran "siamang," three feet tall.

In the same region, precisely eastern Sumatra and Borneo, lives a larger relative, the orang-utan ("man of the woods"), or "mias," as it is known to the Dyaks. Like the gibbons it feeds on leaves, buds and soft fruits, especially the big, pulpy durian; and also like them is shy and mild in disposition.



GORILLAS AND GIBBONS

The five upper figures are young gorillas in various postures; the three lower are adult gibbons. (Lydekker.)

This Malayan ape is smaller and weaker than its African cousins, males standing not more than four feet six inches, and weighing 160 pounds, while the females are smaller. The body is bulky, the belly protuberant, and the legs very short, while the arms are so long that the fingers hang down to the ankle. The coat is a variable dark brick red and long, forming a beard in old males. The head is short and high, with the bony crest of the skull and the ridge over the eyes less prominent than in the gorilla; while the nose is insignificant, and the jaws are large and protrusive, with a long smooth upper lip. The eyes have a pleading expression, the ears are small and closely appressed, and many of the older males have the cheeks greatly and distinctively broadened by flat callosities. Lastly, although its brain is most like that of man, the orang-utan is inferior, in general, to both the gorilla and the chimpanzee.

The chimpanzee and gorilla belong together, not only because both are African, but because they are more closely related to one another than to the Malayan anthropoids. The chimpanzee is to be found in the equatorial forests north of the Congo, and also all along the upper valley of the Nile and about the Great Lakes; but the gorilla seems to be restricted to the rough coastal region between the Congo and Kamerun. Both are black-haired apes, growing nearly to the height of a man of medium size, but with short legs, very long arms, massive chests and shoulders, and huge strength. The face and palms of the chimpanzee are pale flesh color, those of the gorilla black. Both make their homes in trees, feeding on succulent leaves, sprouts and fruit, and like the orang-utans, making nightly platform-

like nests of branches on which to sleep; but the old male gorilla is said to sleep on the ground at the base of the tree in which its family reposes. Both spend much time on the ground hunting for food, and they invade the plantations of the Negroes, who are greatly afraid of them, and wreak much damage there. Dr. Garner, whose investigations of their habits, in his attempt to learn whether they and the monkeys of the region had anything that might be called rudiments of a language, resulted in adding much of importance in regard to them, reported that despite its superior strength, the gorilla was in constant fear of the more active chimpanzee, and fled whenever one approached. The best and most recent observations indicate that the gorilla is not quarrelsome and aggressive, but disposed to hide away from and avoid men whenever it can, rather than to attack them. Nevertheless all these great apes are debased, savage brutes of which nothing good may be said, despite the fact that when caught young chimpanzees, at least, prove docile and able to learn some simple imitations of human behavior; but in old age even they become sullen and dangerous toward trainers who have treated them with uniform kindness. They are base caricatures of men—side lines of development that have proved failures in nature's experiments toward making something out of simian material.

The successful line of human descent began far back of their earliest specific history, and has developed quite independent of these brutal offshoots from some parental stem of which we have no definite knowledge.



